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THE WILDLIFE MANAGEMENT INSTITUTE wishes to express its appreciation to The Wildlife Society and the many individuals, organizations, and agencies that contributed to the success of the Eighteenth North American Wildlife Conference.

THE NORTH AMERICAN WILDLIFE CONFERENCES

The 18th North American Wildlife Conference was the best attended and, in many ways, the most successful in the long history of this series of annual international conservation meetings. Many individuals contributed substantially to the success of this Conference and the Wildlife Management Institute is indebted to them for generous contributions of time and energy. Special mention must be made of the services of Dr. Victor H. Cahalane who represented The Wildlife Society as chairman of the Technical Program Committee. Dr. Cahalane performed outstanding services in formulating, in cooperation with associates of the Society, a well-rounded program of broad interest to all who attended. Dr. C. H. D. Clarke's brilliant and incisive appraisal of the entire Conference program will long serve as a model for future conference appraisers, and his observations will aid greatly in the planning of the next meeting. Dr. Lee E. Yeager has compiled the index for this and for all recent volumes of the Transactions in an efficient and painstaking manner.

The 18th North American Wildlife Conference was the third of these international conservation meetings to be held in the nation's capital. Meeting in the Statler Hotel of Washington, D. C., on March 9, 10, and 11, the Conference was built around the theme: "Natural Resources and Human Needs." One general session and two concurrent technical sessions were held daily. During the three days, 61 formal papers were presented and are printed in this volume with the discussion from the floor as a permanent record of the proceedings.

As in the past the General Sessions section of the Conference is devoted to the basic current problems of renewable natural resource conservation, management, policy, and administration. That section of the Transactions covering the Technical Sessions deals with recent developments in the conservation field and new techniques in the management of renewable natural resources, which were reported upon by the personnel of the various federal agencies of the United States and Canada, the state and provincial fish and wildlife departments, institutions of education, and the many private organizations concerned with the management and restoration of soils, waters, forests, fish and wildlife.

The annual banquet of the Conference, at which Dr. Fairfield Osborn served as toastmaster, was an outstanding success with 875 persons in attendance. The Statler's Presidential Room was filled to capacity and the overflow was great enough nearly to fill the adjacent Congressional Room, which was open to absorb the throngs. Among those attending were more than 150 members of Congress. An outstanding feature of the banquet was the premier showing of Walt Disney's True-Life adventure story "Prowlers of the Everglades" at the close of the customary floor show. The registered attendance of 1,356 broke an all-time record for the North American Wildlife Conferences. Represented in the registered attendance were all 48 states, seven provinces of Canada, Sweden, Pakistan, and Mexico.

As has been customary in the past, many national, regional, and local conservation organizations held regular or special meetings in conjunction with the North American Wildlife Conference. Immediately before this year's Conference a two-day meeting of the leaders of the 17 Cooperative Wildlife Research Units was held. Also attending this meeting were representatives of the state and federal agencies and land grant colleges which participate in the cooperative program. The annual meeting of the National Wildlife Federation was held immediately after the close of the Conference on March 13 and 14. The Wildlife Society, the Wilderness Society, Soil Conservation Society, Society of American Foresters, American Fisheries Society, International Association of Game, Fish, and Conservation Commissioners, President's Quetico-Superior Committee, Izaak Walton League of America, and the North American Wildlife Foundation also conducted meetings during the three-day Conference. The Outdoor Writers Association of America staged an excellent motion-picture show, featuring outstanding outdoor films of the year, on Sunday evening preceding the formal opening.

The Transactions of the 18th North American Wildlife Conference takes its place beside the published proceedings of former Conferences and adds its current record to the important reference library on the management of natural resources which they now comprise.

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PART I

GENERAL SESSIONS

GENERAL SESSIONS

Monday Morning—March 9

Chairman: John A. Hannah
Assistant Secretary, Department of Defense, Washington, D. C.

Vice-Chairman: Harris Collingwood
Analyst in Conservation and Natural Resources, Library of Congress, Washington, D. C.

POPULATIONS VS. A RESOURCE BUDGET

The first general session of the Eighteenth North American Wildlife Conference convened in the Presidential Room of the Statler Hotel, Washington, D. C., at 9:00 a.m., John A. Hannah presiding.

FORMAL OPENING

Ira N. Gabrielson
President, Wildlife Management Institute, Washington, D. C.

It is a great privilege to be present to open another North American Wildlife Conference. These meetings, which are held in various sections of this country, are always a mixture of old friends and of people who are attending for the first time. For the information of the latter, may I outline briefly the character and purpose of these meetings? These Conferences do not pass resolutions nor develop action programs. The attendance is comprised of members of official agencies and organized conservation groups of all North American countries, and of interested individuals who meet to discuss problems of importance and to secure new information that may be available as a result of study and research. The Conference has become a meeting where those interested in soils, waters, vegetation, and wildlife exchange information both publicly and in private sessions, and where plans for cooperative work between groups or individuals are often made.

The chairman of each session is asked not to entertain resolutions nor accept motions. These are functions of the various organizations that are gathered here, and the formulation of action programs should be in their hands. Many of those present will take new information to their organizations for use in initiating new programs or modifying existing ones.

This meeting offers you an opportunity to get acquainted with others who are working in similar lines or who have similar interests. This exchange of information is often the most important contribution that this Conference makes.

Today, there is another chance for you as individuals to do something worth while in the conservation movement. There is a new administration in Washington, and as usual with the advent of a new administration and new Secretaries of Interior and Agriculture, those who have a special interest to serve or who have a desire to get something for nothing descend on the new officials in the hope that they can get from them things which previously have been refused. This is going on today on a larger scale than has been usual in past years. Washington is swarming with people who want something that belongs to the public or who want special privileges and favors above those accorded to other citizens. There is always the hope that they can get something from new officials.

It should be emphasized that conservation has never become a partisan issue. "Ding" Darling, years ago in one of his characteristic comments, stated that in 150 years we have had two conservation-minded presidents, both of them named Roosevelt. Conservationists are looking forward to other presidents with similar principles, whatever their party label may be.

Regardless of the name of the President or the names of the men who are members of the cabinet, and regardless of their party affiliation, those who want something for nothing are always at work. Recently, this capital has had an influx of such individuals, including the political-minded livestock men who seek to get a strangle hold on the public lands equal to that which they have on most of the state-owned lands in the West; miners who want special privileges beyond those now accorded to them by law; and individuals who, in promoting various projects of their own, seek to invade the wildlife refuges; to destroy the national forests; or defile the national parks and monuments. These areas which have been set aside for the public use and enjoyment are always a temptation to gentry of this type. They are here, bringing pressure not only on the new administrators but on their congressmen and senators. The livestock clique is particularly active, and any who doubt their ultimate goal have only to look at the condition of state-owned lands in the West and the quality of administration accorded them.

You have an equal opportunity to present your views as citizens of your state. I suggest that you call on your congressmen and senators and give them your point of view on these and other conservation questions which will be before the Congress. Some good and some bad bills have already been introduced, and others will come. You should, as American citizens, not only express yourself on these questions but go home and encourage your friends and associates to do likewise. I urge you to exercise this right and privilege while you are here. The fact that this Conference is in Washington gives many a greater than normal opportuntiy to do so. So take a little time from this Conference to call your congressmen and senators and visit with them about major conservation problems.

This is your Conference. The General Sessions program has been developed by a committee representing the major conservation organizations of the continent, while the Technical Sessions program is the work of a committee from The Wildlife Society. They are not our programs but your programs, and we hope that you enjoy them. We also hope that you have a good time while you are here; that you make contacts that will be useful to you when you return to your homes; and that you will get information and inspiration as well as pleasure out of this, the Eighteenth North American Wildlife Conference.

INTRODUCTORY REMARKS

JOHN A. HANNAH
Assistant Secretary, Department of Defense, Washington, D. C.

My part in this program this morning is very simple. My only function here is to be the starting and stopping mechanism to see to it that our program train stays on the track and that we finish on time. In stages, we may get off schedule, but at least we shall finish on time.

As you will notice from the program, the speakers are to speak to us for approximately 20 minutes; then we have a period for discussion. The Vice Chairman, Harris Collingwood, will handle the discussion period. I think all of you know Mr. Collingwood as a result of his many years as forester for the American Forestry Association, and his work with the National Lumber Manufacturers Association. Now, as you know, he has a particular responsibility in this area in the Wildlife Conference.

Your program material, and the men who are to present their views to you, are intensely practical; and I am sure you intend that the end result of this great Conference will be some practical ideas for solving some of the basic problems confronting the peoples of the world in the use of natural resources.

At this, the opening session of the Conference, we are to plunge immediately into consideration of some of the fundamental factors in the situation which find increasingly large numbers of people and of nations turning their attention to consideration of food, shelter, health, recreation, energy sources to do the world's work, and other matters intimately associated with the earth and its God-given policies.

Once these were subjects of practical interest to the specialists alone; now we find nearly the whole world wondering whether our resources will be sufficient to meet the needs of all the earth's people in future years; and, as the world's peoples wonder and learn, through the miracles of modern communication, that all nations do not have a proportionate share of resources, we can sense an undercurrent of unrest.

Increasingly large numbers of people are beginning to ask whether they must be content with things as they are, whether they dare not hope and work, and even fight, for the things they believe they too should have.

Here in North America, we are abundantly blessed with many of the resources required to keep us healthy, well fed, and relatively happy; but we are learning that we do not have all of everything we require, so we too are coming to recognize the interdependence of all the world's people and all the world's resources; and we are even beginning to gain a humble understanding of the fact that Providence could not have intended one nation or one race to be favored above all others but meant her treasures to be exploited and utilized intelligently for the benefit of all.

So it behooves us, even from the selfish standpoint of our own security and that of the generations to come, to help the underprivileged peoples and the undeveloped areas of the world to improve their relative standings as measured not against us who are more fortunate, but measured against what intelligent management of the world's resources could produce for everyone.

Happily, modern science and technology offer some hope we would not have dared to hold two or three decades ago. Happily, growing realization of the need for concentrated study and intelligent action has come as science and technology have given us increased hope.

It is my earnest wish, as we open this Conference, that from it may go forth the word that men of knowledge and men of prestige are working together in the determination that the world shall know a better day, that hunger and disease and despair shall be banished from the earth, and that we and our fellow men throughout the world shall be justified in our faith that prosperity and peace are the natural rights of men, and that they are indeed within man's grasp.

And now we proceed to the presentation of the first speaker this morning, who is very appropriately starting off with the subject, "Future Population Trends and their Significance." It is a pleasure to present to you the director of the Division of Population Research of Columbia University, Mr. Kingsley Davis. Mr. Davis [Applause]

FUTURE POPULATION TRENDS AND THEIR SIGNIFICANCE

KINGSLEY DAVIS

Director, Division of Population Research, Columbia University, New York, New York

The interrelation between resources, technology, and population on the one hand, and the level of living or per capita productivity on the other is so complex that it can hardly be stated in words, and no one has yet worked it out mathematically. Yet the subject is of such long-range importance that every effort must be made, with whatever intellectual tools are available, to understand it. The present paper, taking future population trends as its point of departure, cannot deal with all of the implications of population growth, but it can suggest a few of them. Our thesis, however, is not one of demographic determinism. Population is merely one variable in a total equilibrium. Yet it is connected not only with the share each person receives of the national wealth but also with the very process of producing that wealth. It affects the numerator as well as the denominator of the fraction by which per capita real income is derived.

Since we shall be speaking of the future, a note of caution is in order. The student of population, like the student of any other subject, is required to restrain his confidence in his own assertions about the future. It is for this reason that the following discussion begins with a consideration of population projections. The reader must be taken behind the demographic scenes, so to speak, and allowed to see that future populations canot be predicted with any guarantee of accuracy. After this chastening experience, future possibilities can be discussed in the proper vein—*i.e.*, as possibilities rather than certainties.

POPULATION PROJECTIONS

Recently, as a reward for having braved the hazards of projecting future populations, the demographers have been sharply castigated.[1] Enough time has elapsed to prove their flights into the future to be flights from reality. This debacle, though calling for stock-taking and re-tooling, does not mean that projections will, or should, cease to be made. The future population, like tomorrow's weather, is too impor-

[1]The main castigator is an economist, Joseph S. Davis. See his *The Population Upsurge in the United States* (Stanford, Calif.: Stanford University Food Research Institute, 1949) and "Our Changed Population Outlook and Its Significance," *American Economic Review*, Vol. 42 (June 1952), pp. 304-325. In addition, see Harold F. Dorn, "Pitfalls in Population Forecasts and Projections," *Journal of American Statistical Association*, Vol. 45 (September 1950), pp. 311-334.

tant to be ignored. For very practical reasons the meteorologists are asked to figure out the weather in advance, even though their predictions will often prove inaccurate. Similarly, the demographers will continue to respond to the insistent practical demand for population forecasts.[2] They will profit from their mistakes to improve their techniques, but they will never be fully satisfied with their efforts. Fortunately, an estimate does not need to be 95 to 100 per cent accurate to be useful. Furthermore, the greatest accuracy can be achieved in short-run estimates (five, ten, fifteen years). Since human beings cannot plan far in advance anyway, these are precisely the kind of estimates for which there is the greatest need.

Actually the demographers should not be blamed for errors not wholly their fault. To see why population forecasts can never be fully accurate, one must recall how they are made; and for this purpose the distinction between a projection and a forecast is helpful. A projection does not necessarily say what the future population *will* be, but what it *would* be *if* certain assumptions were to hold true. Sometimes an unrealistic projection—*i.e.*, one based on assumptions we do not expect to hold true—can be extremely useful in showing the implications of a current situation.[3] But people faced with decisions respecting the future are not interested in numerical exercises. They want realistic forecasts. A forecast, then, is a population projection based on assumptions regarded as most likely to hold true. The assumptions of the demographer relate to births, deaths, and migration. Given them, he can grind out the figures for the future population by well-known operations. Since, however, these demographic processes are affected by economic and political occurrences, a really accurate population forecast would have, at the same time, to be an accurate politico-economic forecast. Unhappily, the economists and political scientists cannot foresee the future in their fields five, ten, or fifteen years in advance; and even if they could, there is as yet no known technique by which these events can be operationally—*i.e.*, quantitatively—connected with the demographic processes. The American birth rate, for example, continued a steady decline through the prosperous 1920's, but it rose amazingly during the prosperous 1940's. The demographer is therefore forced to resort to what may be called featherbed assumptions. He says that *if* economic conditions remain

[2]This demand is attested by the Census Bureau. "In spite of the fact that earlier projections have not always been borne out by actual developments, the Bureau of the Census is continually receiving requests for projections . . . for use in a wide variety of planning projects. Requests for projections are made by Federal agencies, State and local governments, and private agencies in connection with the development of policies and plans relating to social security, school planning, business expansion, etc." "Population Estimates," *Current Population Reports*, Series P-25, No. 43 (August 10, 1950), p. 1.

[3]Peter R. Cox, *Demography* (Cambridge: Cambridge University Press, 1950), pp. 235-236.

good, or *if* there is no war, or *if* no catastrophe occurs, his assumptions with reference to fertility, mortality, and migration will likely hold true. But he has no way of ascertaining whether or not these politico-economic conditions will or will not prove real; his statements about them are spongy and amorphous, because these conditions are not quantitatively defined and cannot be mathematically connected with demographic events. Seen in this light, population forecasts are obviously hazardous undertakings. They resemble the prediction that a drunken driver will reach his destination by a certain time *if* he has enough gasoline, *if* he stays on the road, and *if* he does not decide to go elsewhere; his gasoline supply can be ascertained, but it is impossible to assess in advance the other two factors.

From the standpoint of improving the accuracy of forecasts it is instructive to examine the mistakes made in the past. In general it can be said that demographers, in common with nearly everybody else, have had their view of the future too much distorted by events of the moment. Most of the projections made in Europe and America during the nineteenth century, when population growth was rapid, overestimated future numbers.[4] Some of them were accurate over the short run, but nearly all tended to be too high several decades out. On the other hand, the estimates made between 1930 and 1945 tended to give too much weight to the special conditions prevailing during the great depression. Owing to the sharp fluctuations in business conditions and the sensitivity of demographic behavior to these conditions in recent times, the estimates made during the last two decades have tended to be wrong even over the short run—nearly all underestimating the population. Thus we find that in Britain nine projections of the population published between 1935 and 1944 all fell below the census figures for 1951 by substantial amounts, as shown in Table 1. Notestein and his co-workers estimated the future population of European countries up to 1970. As of 1950 the box score for 15 countries whose boundaries had remained virtually constant was 14 underestimated and only one (Ireland) overestimated. The average error was 4.7 per cent, and 8.33 million short on 15 countries totaling 169.66 million in 1950. Notestein and his co-workers consistently underestimated the 1950 populations because they relied too heavily on the interwar experience. As they said, the projections assume "an uninterrupted orderly development of interwar vital trends."[5] Curiously, the authors regarded the war as the main factor that might

[4]Dorn, *op. cit.*, pp. 315-317. Joseph J. Spengler, "Population Predictions in Nineteenth Century America," *American Sociological Review*, Vol. 1 (December 1936), pp. 905-921.
[5]Notestein et al., *The Future Population of Europe and the Soviet Union* (Geneva: League of Nations, 1944), p. 237.

TABLE 1. ACTUAL AND PROJECTED POPULATION FOR 1951 IN GREAT BRITAIN

	Population in Thousands		
	England and Wales	Great Britain	Percentage Error
Actual Population[1]	43,745	50,212	
Projected Population[2]			
Enid Charles (1935)			
No. 1	40,678*		7.0
No. 2	39,766*		9.1
No. 3	43,164*		1.3
D. V. Glass (1940)			
No. 1	41,312*		5.6
No. 2	42,863*		2.0
No. 3	40,714*		6.9
F. J. C. Honey (1937)		44,989	10.4
F. W. Notestein et al. (1944)		46,110	8.2
Registrar-General (1942)		47,501[3]	5.4

*These projections are for 1950 rather than 1951, but the rate of change envisaged is so slight that this makes no important difference.

[1]Preliminary Census return.

[2]From Peter R. Cox, *Demography* (Cambridge: Cambridge University Press, 1950), pp. 258-259.

[3]The Registrar-General gave a margin of plus or minus 280 for his figure, but this margin was not sufficient to bring his projection up to the actual figure.

throw their projections off, but they were thinking of its effect primarily as a cause of abnormally high mortality. Since they made no attempt to take into account war losses in their projections, they repeatedly spoke of the death-rate estimates as valid only for "peacetime" mortality and implied that the projected populations would thus probably prove to be too *high*. Actually, the big upset in the projections did not come so much from the mortality side as from the fertility side. Even though the book was published in 1944, the extraordinary rise in the birth rate in Western societies which had already set in at that time was largely ignored (probably because most of the calculations were done during several years prior to publication and because one's demographic data are always of necessity somewhat out of date). The result was that whereas the authors feared their projections might prove higher than the actual future populations, the estimates actually turned out to be lower, as we have seen. It can hardly be maintained that the development of trends after the interwar period was not "orderly." From a scientific point of view, any occurrence must be viewed as orderly in at least some explanatory context. It is better to say that Notestein and his co-workers did not correctly perceive the order that was there and which would give the key to future developments. Their mistakes, which were honest mistakes and the kind any of us would have made at that time, have served to show the necessity of using new techniques in the interpretation of trends in human fertility.

It has been shown, especially by John Hajnal, that current fertility rates, however they are measured (whether as crude rates or refined in one way or another), afford no adequate guide to future reproductive behavior.[6] The reason is simple: in Western society, where birth control plays a great part in reproduction, a couple's decision to have or not to have a child *this* year will greatly influence their decision in this matter *next* year. Indeed, it appears from available data that the number of children a Western couple will *ultimately* have tends to be, in the mass, a rather stable figure, but that the decisions as to *when* they have their children is highly variable. Consequently, in a period of intense economic depression, both marriages and births may be so few as to yield low rates. But to assume that this is part of a long secular decline is a mistake, because the very fact that many couples have refrained from marrying or from having children means that both the marriage rate and the birth rate will subsequently rise when condtions become more propitious. It follows that fertility must be analyzed by longitudinal techniques—by the study of the behavior of cohorts (people of the same age) over time, the study of births by birth-order and age of mother, the study of trends, if any, in completed fertility. In view of the interest being shown in these newer techniques of analysis, we can say that the demographers are profiting from their past mistakes.

The experience of forecasting the population growth of the United States has been no better than the experience with respect to Europe. In 1934, for example, Thompson and Whelpton estimated that our inhabitants in 1950, on the basis of medium assumptions, would be about 140 million.[7] The figure according to the census of 1950 was 151 million. The authors thought it quite possible that "within two or three decades" our population would become "stationary at somewhere between 135,000,000 and 145,000,000." Today, 18 years later, we have 160 million, and few experts are willing to talk about a coming cessation of our population growth. The text of the discussion shows that Thompson and Whelpton were greatly influenced by the rapid decline in current fertility rates; they also took a dim view of prospects for further improvements in longevity and further immigration. In 1937, still influenced by phenomena then current, their *high* estimate yielded a total of only 147 million by 1950—four million lower than the figure actually turned out to be. Their low estimate was 137 million, 14 million below the actual figure.[8] By 1945 Whelpton, who had been in the projections business for over a decade, realized that the "baby boom" was the factor mainly responsible for the

[6] J. Hajnal, "The Analysis of Birth Statistics in the Light of the Recent International Recovery of the Birth-Rate," *Population Studies*, Vol. 1 (September 1947), pp. 137-164.
[7] New York *Times*, Sunday, March 18, 1934, Section 8.
[8] National Resources Committee, *Population Statistics: 1. National Data* (Washington: Government Printing Office, 1937), pp. 19, 21.

failure of the earlier forecasts. But in preparing the new ones he did not see fit to alter his assumptions by very much.[9] Consequently, only five years after publication, his *highest* estimate was already more than three million too low, his lowest estimate over seven million too low.[10] It is little wonder that Joseph Davis has made his attack on the demographers' clairvoyance and that the Census Bureau has become demoralized on the subject of future population trends. The Bureau published in 1950 a set of "illustrative" projections for 1950 to 1960.[11] With self-protective caution, this study found that the population of the United States would be, according to the high estimate, 180 million in 1960, and, according to the low estimate, 161 million. In other words, the Census Bureau gave itself leeway to be, within ten years, 19 million off. Almost two years later the population growth was found to be matching their highest estimate. In fact, the birth rate, the main component of population change, was running ahead of the projected rate. It had been "assumed to decline considerably from its 1949 high. However, since 1949, in some degree because of the Korean war, the birth rate has continued at approximately its 1949 level."[12] So a revised estimate for the period 1953 to 1960 had to be prepared, the totals this time coming out to 180 million for the high estimate again and 165 million for the low estimate, a leeway of 15 million in seven years.

One can defend the earlier estimates by saying that, though they have proved wrong over the short-run, they may yet prove right in the long run. Notestein, it will be recalled, ran his projections out to 1970. Thompson and Whelpton ran some of theirs out to 1975, 1980, and even the year 2000. It is quite possible that the unexpectedly high and unexpectedly long spurt of population growth in Western countries is temporary and that the secular trend of a declining rate of growth will soon be resumed. If, however, the authors of projections believe that their long-run estimates will eventually prove more right than their short-run figures, they should hardly want to revise their projections every few years; yet this is what some of them have done. Thompson and Whelpton in 1937 found that the U. S. population of 1980, according to their medium assumptions, would be 159 million. In 1945 Whelpton found the 1975 population would be, again by medium assumptions, 170 million, which is 16 million greater than

[9] P. K. Whelpton, *Forecasts of the Population of the United States*, 1945-1975 (Washington: Government Printing Office, 1947), p. 1.
[10] *Ibid.*, p. 41.
[11] "Illustrative Projections of the Population of the United States, 1950-1960," *Current Population Reports*, Series P-25, No. 43 (August 10, 1950).
[12] Bureau of the Census, "Provisional Revision of the Projections of the Total Population of the United States: July 1, 1953 to 1960," *Current Population Reports*, Population Estimates, Series P-25, No. 58 (April 17, 1952).

he had earlier projected for 1980. Actually, it is of the nature of so-called component projections (those which analyze trends in births, deaths, and migration in arriving at total population figures), that an early deviation from the expected numbers causes a deviation at later dates as well.

If, then, we wait for the long-run projections to prove right despite temporary boggles, the question is, which long-run projections? The truth is that there is no rational way of predicting future population trends over several decades. One might as well be wholly empirical and extrapolate a curve fitting the past population growth and conforming to the general pattern found often to repeat itself in human populations. If the inflection point in growth has already been passed, the so-called logistic curve seems as good as any for guessing what the long-run trend might be—given an "orderly and smooth" development in the affairs of the country concerned. A logistic forecast made by Pearl and Reed prior to 1920 for the United States missed the 1950 population by only 1.3 per cent, which is by far the best record so far achieved in American forecasting. Their forecasts for several other countries, on the other hand, proved to be very wide of the mark, and their figure for the world as a whole for 1950 was too low by 27 per cent.

THE WEST VS. THE WORLD AS A WHOLE

One of the interesting aspects of the recent upsurge of population growth in the West is that it was in the advanced countries that the demographers first found the signs of an eventual cessation of growth in the world as a whole. It was thought that if the pattern of an efficient population balance—a balance based on *low* birth rates and *low* death rates—could be gradually extended round the globe, the present extremely fast pace of world population growth could eventually be reduced in a rational manner and the world possibly saved some major difficulties. To be sure, observers were always a bit uneasy about the disequilibrium in growth between the advanced quarter and the unadvanced three-fourths of the world, but so long as this could be a temporary disequilibrium, it did not seem so bad. Now, however, at least temporarily, the advanced countries have themselves given a fillip to the world's currently amazing population growth. At the same time, the more undeveloped countries have not been standing still. Events are occurring which have sent their populations plunging ahead. If, therefore, we take a look at the world's population as a whole, we find something that is disquieting. We find that it is growing faster today than it has ever grown before, and at a speed that cannot possibly be continued for very long. One may be tempted to say that part of this rapid growth may be fictious, that it is due in some measure to better census methods.

	Millions	Average Annual Per Cent Growth
1650	465	——
1750	660	0.29
1800	836	0.44
1850	1,098	0.51
1900	1,551	0.63
1950	2,400	0.84

But the interesting thing in this regard is the fact that the fastest growth is the most recent. Between 1940 and 1950 the rate of growth was the highest of all, being approximately one per cent per year for that decade. The amount of improvement in census taking during this century has not been great enough to account for this increase in the rate of growth. In fact, censuses sometimes show less population than was previously estimated. There is no indication that we are yet at the peak rate of growth.

Now let us make a *hypothetical* projection. Suppose the world's population were to continue at the rate observed between 1900 and 1950. It would grow as follows:

2000	4.4 billion
2050	8.1 billion
2100	14.9 billion
2150	27.4 billion
2200	50.4 billion

I call this a hypothetical projection because I do not believe it has the least chance in the world of actually happening, but it is useful in showing the implications of the growth trend during the last half century. One of the implications is to show how exceptional this growth trend is and how inescapable the fact that it cannot continue. Something must stop the trend; something will stop it.

Whatever stops the world's population growth will be something that happens in the underdeveloped parts of the world. The reason is, first, that these areas embrace (by one method of measurement) 76 per cent of the world's people, or almost exactly three-fourths; and, second, they are the ones that are at the beginning of the demographic transition and which have the greatest growth potential before them.

What will happen to these underdeveloped areas in the next four to ten decades to alter the population trend? There appear to be only three possibilities: (1) A gradual industrialization and modernization which *eventually* will affect fertility as it has done in the now industrialized countries. (2) A decline in fertility *prior* to such industrialization and modernization. (3) A rise in the death rate. In my estimation all three of these are definite possibilities—none can be ruled out on prior grounds. But also, in my opinion, none is likely to be the sole factor. My guess is that they will all be involved, particularly number 2 and number 3.

Usually number 1—gradual industrialization and modernization—is thought to be most probable and is most stressed from a policy point of view. But I have little confidence in it alone turning the trick. The reason is that the normal population growth that accompanies industrialization seems too great for the underdeveloped areas as a whole to stand and still manage to industrialize. For example, Japan had in 1951 a population almost two and a half times the one it started its industrial expansion with some 83 years earlier. But, you say, Japan did industrialize. Yes, but it has not yet completed the demographic transition. Its population is still growing at a rate of 1.7 per cent per year (as between the censuses of 1948 and 1950), which is nearly double the world average. It must be remembered that the demographic transition—the change from a regime of high birth and death rates to one of low birth and death rates, with accompanying rapid growth until fertility is adjusted to the low mortality—lags behind the industrial transition. Furthermore, Japan's dense population has always caused her economic difficulties and is certainly doing so now. She has never achieved anything like the standard of living that Western industrial nations have achieved. Population growth is one of her major problems today, if not *the* major problem, and will continue to be for some time yet.

You may argue, of course, that industrialization can come more rapidly now than it used to come, that it can be even more rapid in India, Indonesia, Egypt, Ceylon, Pakistan, and the other crowded areas of the world than it was in Japan. This is true. It *potentially* can be. But in the field of future developments I am very leery of potentialities. If I were not aware of the painfully slow progress being made in most of Asia, in the Caribbean, and in other backward areas—slow progress in the face of population growth—I would be more sanguine. But the fact has to be faced that, according to the FAO, world food production, for example, has been increasing at a slower pace than population since before the last war. Conrad Taueber says: "In countries in which the food and nutrition situation was generally satisfactory before the war it (the food situation) has been maintained and even improved; but in countries where people historically have had too little food, the situation has grown worse. And these countries of lowered food consumption include more than half of the world's population."[14] It must also be borne in mind that if industrialization can potentially be more rapid than now, so can population growth. The direct transplantation of modern public health measures and medical techniques in underdeveloped areas is cutting death rates by a fourth to a half in the space of only a few years and yielding staggering rates of population growth beyond the dreams of the now industrialized nations when they were at a similar period of economic development. As a result of this situation there can be little doubt that the increase of numbers and growing densities are interfering with, and may (if continued) prevent the very process of economic development which is ultimately supposed to relieve the population growth.

So we come to the conclusion that the already densely settled peasant-agricultural countries are not in the situation that the Western peoples or Japan were in prior to their industrial and demographic transition. They do not have the prospect of industrializing in a world with many virgin territories and few or no already industrialized nations present. Their current population growth is more rapid than it was then. Their densities are great, their living standards low. The supposition that they can go on through a smooth and painless process of industrialization, experiencing at the same time such an enormous population growth as this would imply, hardly seems tenable.

I do not mean to imply that these countries will not modernize themselves. It stands to reason that they will, because the enormously greater efficiency that advanced cultures manifest is too overpowering not to be copied and achieved by the rest of the world. It hardly seems likely that the world will continue to be bifurcated into two extremely unequal parts, the one living in the archaic and inefficient economy of peasant-agriculturalism, the other enjoying the advantages of a modern urban-industrial civilization. Nor do the facts of what is happening point to a continuance of this situation.

I am arguing simply that the industrial transition will not be achieved under the present condition of extraordinarily rapid population growth. This leads us to the second possibility mentioned before—a possible rise in the death rate. Frequently, this conceivable eventuality is not discussed because we do not like to think about it. But as scientists we cannot pursue an ostrich attitude. We now have —in atomic energy, in bacterial warfare, in giant planes and guided missiles—weapons of fantastic deadliness. But even more to the point,

[14]Conrad Taueber, "Utilization of Human Resources in Agriculture," Milbank Memorial Fund *Quarterly*, Vol. 28 (January 1950), p. 70.

some of our population densities are now built on houses of cards. As the famine in Bengal in 1943 illustrated, even small dislocations in the transport facilities and economic life of some of these countries can produce losses of life running into the millions and probably into the tens of millions. People can be killed quickly, far more quickly than their numbers can be built up again through reproduction.

There is a tendency to view large-scale catastrophe of this sort as dealing a great blow to economic advance and social change. This is indeed sometimes the case, but it depends on how it comes about. The opposite is often true. Warfare, revolution, social disruption, have often opened the way to social change that seemed virtually impossible otherwise. In such catastrophes old institutions, old entrenched and traditional obstacles, tend to be swept away. Furthermore, in countries suffering severely from population pressure, the very writing off of a substantial portion of the human mass may afford opportunities for economic development which were precluded before. This is why I think that possibility 1 and possibility 2 are not mutually exclusive. It may turn out, since population is a heavy obstacle at present, that urban-industrialization will actually be accomplished through the unintended but nevertheless effective eventuality of sudden and catastrophic increases in mortality. Yet few people, other than misanthropists, can look with equanimity on this kind of a process actually occurring. This is why a growing body of opinion throughout the world is taking seriously the third possibility—the chance of stopping population growth and facilitating rapid industrialization by lowering fertility directly and quickly in peasant-agricultural areas.

This would be, it must be admitted, a revolutionary step, because it has never been done before. Always in the past the reduction of fertility has come as a *consequence* of the development of an urban, industrial, mobile, competitive social order. This suggests to many observers that it cannot be done any other way. But if nothing occurred in the world which had not occurred before in history, there would have been no cultural development at all. The industrial transition itself was a revolution, because it had never happened before. There is no inherent reason why peasant-agrarian populations cannot adopt the custom of fertility control, in advance of and to the advantage of modern economic development. We certainly do not know that it cannot be done, and one reason we do not know is the fact that it has never been tried.

True, there have been attempts to introduce birth control clinics in backward areas, with mediocre results. Beebe's studies of such an attempt in the Southern Appalachians and in Puerto Rico are interesting in this regard.[15] But the attempts have been half-hearted. Simply setting up a clinic, using our middle-class birth control methods, and inviting people to come in from the country, with no accompanying propaganda and education, could hardly be relied upon to solve such a stubborn and deep problem as the one we are considering. But the pressure is now getting so great, the concern so widespread and strong, that governments are getting interested. Furthermore, the technical side is being pushed more than it has been before, and may be pushed still further in the future. If new technical advances in fertility control can be made—providing a means that will be independent of the sex act, which will endure for a long time, which will be cheap, easy to employ, and yet efficient, advantage can be taken of the weak but nevertheless manifest desire among hard-pressed peasant-parents everywhere to space and limit their births in a reasonable fashion. If such technical advance should be matched by the creation and use of mass educational techniques, mobile teams used to give medical attention and fertility control advice, backed by government financing and government prestige, the results may prove astonishing to the skeptics.

My experience in India opened my eyes to some of the possibilities. There the government has appropriated substantial funds for the advancement of fertility control. There the people are becoming widely interested. There the absence of religious taboos offers a favorable environment. Similarly, the government's interest in birth control in Puerto Rico, despite the presence and objections of the Catholic clergy, is also instructive. The peasant-agriculturalist today, in almost every part of the world, is in a different situation from the one he was in a century or so ago. The very population growth has affected his situation and his outlook. It has caused holdings to be smaller, prices of land to be higher, procurement of his produce by government requisitioning more frequent, rationing schemes more prevalent. The reduction in the death rate of children has caused his family to be larger than ever before, even with the same fertility or a slightly lesser fertility. Increased commercialization of agriculture has caused him to participate more in a money economy. Nationalist movements and recent political independence have caused him to take more of an interest in political affairs. News of the wider world is seeping into his village—news that things can change, news that better ways of living

[15]See Gilbert W. Beebe, *Contraception and Fertility in the Southern Appalachians* (Baltimore: Williams & Wilkins, 1942); also Beebe and Jose Belaval, "Fertility and Contraception in Puerto Rico," *Puerto Rico Journal of Public Health and Tropical Medicine*, Vol. 17 (September 1942).

are possible. It is a mistake, then, to reason as if he were governed by exactly the same mores and institutions that determined his behavior in past times. Even the joint and stem family is breaking down. Some education is penetrating. Increased social and geographical mobility is making its appearance. The possibility of interesting these peasant-agriculturalists in fertility control is not necessarily an idealistic pipe-dream, but it will be so hard to accomplish that it will require great effort, brilliant ingenuity, and huge resources. It will also require technological and social research.

One may, of course, be pretty sure that this will not actually prove to be the sole and adequate solution of the problem of world population growth and its effects. The task is too great, human beings are weighed down by too many religious and moral taboos, and time is too short for such a rational and collective approach to human reproduction to be entirely successful. But it may help, and it may make the solution through rising death rates less widespread. It is by no means an alternative to be chosen in place of economic and social development. There is no inconsistency between these two approaches whatever, and it is unfortunate that the logic of human controversy is such that nearly every problem gets defined in terms of an either-or issue. Actually, the course of development in human affairs—as apart from human argumentation—has little respect for logical alternatives, and even less respect for falsely opposed alternatives. Mankind will probably muddle along to a more generally higher level of living, a more efficient demographic balance, a new kind of society and economy, by all three of the ways in which population growth can be lessened.

In the meantime, however, the crucial fact for Americans to bear in mind is that their chief population problem during the next few decades does not lie within their own borders. In all probability, the United States, like other industrial nations, will not continue its present rapid population growth; the peculiar circumstances behind the 1940-1953 baby boom will disappear and massive immigration will not be renewed. But the combination of poverty and rapid population growth in the rest of the world is a vital matter to us. With the highest living standard of any nation, we live on the rest of the world. We consume more industrial materials than we produce, and are destined to do so to an ever greater degree. Already we consume about half the materials of the free world.[16] If rapid population growth continues in the rest of the world, particularly in underdeveloped areas, the result will be an ever greater demand on already scarce

[16]See President's Materials Policy Commission, *Resources for Freedom* (Washington: Government Printing Office, 1952), pp. 2, 59.

resources which we need in constantly greater abundance. If at the same time the level of living of the world population should rise, as everyone hopes it will, then the demand for resources will be multiplied by this factor in addition to that of population growth. Every American, therefore, in contemplating his future and that of his country, has a stake in population trends abroad. It is profoundly to his interest to have the current aberrant expansion in human numbers cease.

DISCUSSION

CHAIRMAN HANNAH: Thank you very much, Dr. Davis. We started a little late this morning and are going to pick up by degrees as we go along. Instead of having ten minutes for discussion, as is scheduled on the program, we are going to cut this discussion period to five minutes. I am now going to turn the meeting over to Mr. Collingwood. There are to be no debates. The nature of the discussion, we hope, is to be in the direction of permitting you to ask the speaker questions to bring out the points you think have not been made adequately clear in the presentation.

MR. HARRIS COLLINGWOOD: We will open it up for discussion of Dr. Davis' very interesting and thought-provoking paper. Unfortunately, for the present at least, there is not time for complete discussion.

And now, ladies and gentlemen, have you any questions or any suggestions which will help Dr. Davis to make his points more clear? Perhaps you were somewhat overwhelmed by some of the unusual terms; perhaps you were a little bit nonplussed by the fact that he speaks of the large birth rate as one which is unfortunately high, especially during periods of prosperity. I think you should realize that, when he speaks that way, he is talking in terms of a scientist and a cosmographer, and not in terms of a parent.

However, we are not parents; we are a group of men and women interested in the welfare of the world.

I notice that our next speaker has arrived. I know his time is limited; I am going to turn the microphone over to Dr. Hannah.

CHAIRMAN HANNAH: The lack of questions should indicate to Dr. Davis that his presentation was well done.

The next speaker is a very busy man; we are very happy that he is able to be with us here this morning. There are two members of the Cabinet who are of particular interest, always, to those of us concerned with conservation. These are the Secretary of Agriculture and the Secretary of the Interior.

There has been much conjecture in the public press as to what the attitude of the Secretary of the Interior was to be toward some of those matters which are of concern to us. The best place to get acquainted with a man is in his own home surroundings. Those of you who come from the far West, those of you who come frm Oregon, know of the very high regard with which our speaker is held in his own community. He started at the bottom of the ladder, became a successful businessman in Salem, a state senator and, until he assumed his present responsibility, the Governor of the State of Oregon.

It is a very great pleasure for me to present to you Mr. McKay, the Secretary of the Interior. [Applause]

RESOURCES FOR THE FUTURE

DOUGLAS MCKAY
Secretary, Department of the Interior, Washington, D. C.

I deeply appreciate the invitation of my good friend, Ira Gabrielson, to speak to this group which is devoted to the preservation of the wildlife of the North American continent and to the conservation of our natural resources. First, I wish to extend to the Conference the greetings of President Eisenhower and to convey to you his sincere regrets that he could not accept your Chairman's kind invitation to address you today.

I am pleased to have the opportunity to become acquainted with you, and I am sure you would like to know something about the views of the new Secretary of the Interior. This is my first formal speech as Secretary of the Interior. I did not want to accept major speaking engagements before I had had time to become better acquainted with the varied and far-flung responsibilities of the Department of the Interior. I am not new to the field of resources management. For many years, I have taken an active part, first as a member of the Oregon Legislature and later as Governor of Oregon in the multiple-use development of resources in the Willamette Valley and other parts of Oregon. Also as Governor, I served on the Columbia Basin Interagency Committee, along with the Governors of Washington, Idaho, and Montana, and representatives of the Departments of the Interior, the Army, Agriculture, and Commerce, the Federal Power Commission, and the Federal Security Agency. Furthermore, I was the first Governor of Oregon to set up a Natural Resources Committee from among the heads of the executive departments of the State of Oregon. The Committee met regularly in my office, and during my term as Governor it was formally established by an act of the Legislature.

I am in accord with the broad purposes of the organizations represented at this conference. These purposes in effect are to preserve intact certain parts of man's natural environment. Generally, I like any landscape or environment as it exists in nature much better than after man has cluttered it up with his own works. I remember with pleasure the Oregon countryside during my early boyhood. Although western Oregon had been settled for several decades, the population was still sparse in the rural areas and much of the wild character of the country remained. Since that time, the phenomenal growth of the population and the progressive cutting of the timber have altered the landscape radically. There still are extensive areas of wilderness and semi-wilderness in Oregon, but they are much more remote from the towns and villages than they once were.

Naturally, I realize, as you do, that we cannot preserve all, or even the major portion, of the landscape in its natural state. We can provide for the growing needs of our expanding population only by continuing to clear and cultivate more soil, produce more timber, mine more coal and other minerals, prospect and drill for more oil and gas, and dam more streams to generate power, irrigate land, and control floods. All these developmental activities are necessary to provide the environment for a high level of civilization. At the same time, we cannot forget that civilized living for most persons also requires frequent access to open country, either unaltered or only slightly altered by the activities of man.

Our problem is to provide for an orderly, balanced development of our resources, so that our needs for all the products and services of the land may be met. That this is no simple task is well known to you who have fought many a battle to protect our parks and wildlife resources against the encroachments of power dams, drainage and irrigation projects, and oil and gas development. It is particularly difficult in the case of wildlife and fisheries protection, since an expanding population and improving standards of living exert a relentless pressure on wildlife and fisheries habitat, while at the same time demanding larger populations of fish and wildfowl for fishing and hunting. The outlook is far from gloomy, however, if we remember that fish, wildlife, and recreation are receiving increasingly greater recognition as fundamental components of balanced resource development, and that the current river basin programs in many parts of the country provide good opportunities for not only the protection but also the enhancement of our wildlife, fisheries and recreational resources. I sincerely hope that we will take advantage of every opportunity for constructive action in this field.

Feeling as strongly as I do about the need for preserving our wildlife and recreational resources, I almost wish in some ways that the Secretary of the Interior had no other responsibilities. But the fact remains that I do have other responsibilties which impose upon me an equally heavy obligation. Included among these are not only the development of water resources for multiple purposes, including irrigation and power, but also the less publicized functions of promoting the orderly development of our public lands which are so important to the Nation's grazing, timber, and mineral industries, and administering the trusteeship of Indian resources. In the exercise of these responsibilities, I shall attempt to maintain a balance between the developmental and the protective concept. A discussion of problems now before the Department of the Interior will indicate the difficulty and variety of decisions which have to be made in the course of our work.

I shall mention first a problem with which I am personally acquainted—the Rogue River in southwestern Oregon. I have been interested in this matter for the last several years as Governor of Oregon and I now find that I shall have ample opportunity to continue this interest as Secretary of the Interior, for it is high on the list of policy decisions in the Department. The Rogue River Valley has received a great deal of national publicity and, as I am sure you are well aware, is among the few remaining basin-wide natural recreational areas left on the Pacific Coast. The Rogue River rises on the edge of Crater Lake National Park in the high Cascade country. In its upper reaches it flows through magnificent stands of timber in the Rogue River National Forest, where no commercial developments which would be incompatible with the use of the river for recreation have been permitted. Through its lower reaches it flows through country so rugged and remote that no commercial development of any consequence has occurred, and the river is accessible only by shallow-draft boats. While the more level Middle Valley of the Rogue has been highly developed for agriculture and industry, even there the river is heavily used for recreation. A stretch of the river above Grants Pass which is closely hemmed in on one side by U. S. Highway 99 and on the other by the Southern Pacific Railroad tracks is nevertheless lined with recreational developments, apparently because of the good fishing which is offered during the spring and fall by the runs of salmon and steelhead trout.

Naturally, the recreation industry is one of the principal economic supports of the Rogue River Valley. It grosses several million dollars every year. Since recreation is so dependent upon preserving the natural characteristics of the Basin. there has been substantial opposition to any further economic development of the river. This opposition comes from many quarters, including sportsmen and recreation seekers and those in the business of serving them, as well as from regional and national organizations interested in protecting the wildlife, fisheries, and natural beauty of the Basin. As I have indicated, I am sympathetic to their point of view.

I am also aware, on the other hand, of the increasing pressure for further development of the river for irrigation and power purposes. The persons and organizations espousing this kind of development are as earnest in their beliefs as their opponents. I personally believe that it will be possible to strike a proper balance between the two divergent points of view, and hope that in the near future there can be at least a limited amount of development which will not be in conflict with wildlife and recreation interests. The Rogue River remains, however, a good example of how difficult it is and how long it can take to achieve agreement among the citizens concerned as to what constitutes proper balance in the development of our natural resources.

Moving now to the Pacific Southwest, I should like to discuss briefly a rather unusual problem that has recently come to my attention. The Department of the Interior is currently concerned with the disposition of several thousand square miles of land along the Lower Colorado River. These are lands which were placed under Reclamation withdrawal some twenty-five years ago in connection with development of the river under the Boulder Canyon Act. Now that construction on the river is substantially completed, these lands are no longer needed for this purpose and will be returned to the public domain for appropriate disposition under the public land laws. Since the proximity of these lands to the river gives them a unique importance in the semiarid vastness of the region, there are numerous demands for the use of the lands. These demands, from both public and private sources, are varied in nature and to a considerable degree mutually conflicting. Representatives of the several Interior bureaus concerned and the States of Arizona, California and Nevada have been working as a special committee in an effort to agree upon an over-all land-use plan for the area.

While I do not have time to describe all aspects of the problem, which are interesting as well as complex, I do want to mention one facet of the problem in particular. The Division of Beaches and Parks of the State of California has recommended that portions of the land be used for the establishment of six state parks, of different sizes, along the California side of the river. The National Park Service and the Department of the Interior have regarded this recommendation very favorably, since there are at present no state or county parks in the area in spite of the increasing pressure for recreation facilities from the growing metropolitan centers of southern California and Arizona. Opposition to the proposed state parks has been expressed by the State Engineer of California because of unsolved legal problems related to land and water rights. Opposition from this source was not unexpected. It was rather surprising, however, to find an organization of sportsmen in southern California opposed to the two largest of the proposed parks. Their opposition is based on the fact that no hunting is allowed in state parks. Thus we find the park supporters and the sportsmen, who generally stand shoulder to shoulder in fighting economic encroachment, disagreeing among themselves as to the proper use of an area. In effect, therefore, we have "intramural" conflicts of interest as well as the "development vs. preservation" conflicts to consider in our struggle to find the right answers.

Now I should like to move quickly across our great country and give you a few of my thoughts about the eastern United States. Although a native and lifelong resident of the Far West, I am nevertheless well aware that the East and Middle West have their share of the Nation's natural resources as well as the problems that go with them. Since most of the resources in the East have been utilized in one way or another during the last two centuries, many of the problems are quite different from those in the newer western states. With far more people and relatively little unoccupied land, the pressure upon the natural resources is tremendous. It is all the more important, therefore, that we devote our most careful attention to proper development and protection of our eastern resources. It is the joint responsibility of all citizens, of organizations such as those represented here today, and of our local, State and Federal Governments to see that this is done.

I believe that remarkably good progress has been made in this part of the country. The East can take pride in its four great national parks. Each of them—Acadia, Shenandoah, Great Smoky Mountains, and Everglades—well merits the distinctive designation of national park. Their great value is certainly attested by the fact that two of them — Great Smoky Mountains and Shenandoah — have the highest number of visitors among all the national parks.

The states too have made progress in this field. The State of North Carolina, for example, deserves great credit for its vital role in acquiring lands for the establishment of the Cape Hatteras National Seashore Recreational Area. I am sure that all of you have been as pleased as I am that the joint efforts of the State, the National Park Service and two private foundations are making possible the permanent dedication of this beautiful strip of unspoiled coastline to the enjoyment of all citizens. I understand that it took fifteen years to complete the arrangements, but it is worth it. Since the seashore is a limited resource of great importance to the people of the United States for wholesome recreation, all levels of Government should cooperate in acquiring enough of it to meet the public needs. New Jersey likewise deserves our praise for its program to establish Island Beach as a state park. Several other eastern states have also shown fine foresight in expanding and improving their state park systems, and I hope all of them will give constant attention to this important state responsibility.

It is gratifying also to find good progress in the establishment of waterfowl refuges along the Atlantic Flyway. The Fish and Wildlife Service has cooperated closely with the States in this program which is so important to the thousands of hunters who flee the crowded cities at every opportunity.

But we must not sit back and relax. While the results to date are good, there is more work to be done. We should continue comprehensive resource investigations such as those now being carried out by the Federal Inter-Agency Committees in cooperation with the States in the New England-New York area and in the Arkansas-White and Red River Basins. Both the Fish and Wildlife Service and the National Park Service, as well as their counterpart State agencies are playing important roles in these studies. I believe the results will be of substantial value to the respective regions.

In conclusion, I should like to mention that since I have been in Washington, I have received a great volume of letters and have read numerous editorials, some of which naturally have expressed concern that the public resources might be dissipated during the new administration.

It is true that any change in Government administration offers an opportunity for advancement of claims by those who would exploit the public resources for their own gain and the public loss. Such claims are not new; they have been asserted loudly during every administration. They can be dealt with if the people remain alert. The advent of a new administration is a proper time to review the existing policies for management of the public resources to determine whether such policies may be improved. In this review, we must give all those individuals and groups who make their living from the public resources, as well as those whose interests are materially affected by the methods of public resource management, full opportunity to be heard, and we must expect that some changes in policy will result. I can assure you, however, that so far as I am concerned personally, such policies as are evolved will be only those which in my considered judgment will provide stronger safeguards for the interest of the entire Nation in our public resources.

DISCUSSION

CHAIRMAN HANNAH: Secretary McKay, the North American Wildlife Conference, and we who are in attendance, are greatly honored on this historic occasion, your first official statement before the public.

We are also greatly relieved, if any of us had any fears, by this fine statement especially at the conclusion of your address.

Now I am sure, with so many men and women here from the federal agencies and from the agencies throughout all states, that there are those who would like to ask the Secretary some questions, perhaps clarify some of the points he has made. I will entertain any questions or comments.

Apparently, Mr. Secretary, you completely satisfied them.

SECRETARY McKAY: Thank you, Mr. Chairman. I just want to say this. I dislike very much reading speeches publicly; but this speech must, of necessity, be read, because I want to be sure I am not misunderstood.

Let me say to you this before I leave. I was hoping somebody would ask me some embarrassing questions but, apparently, they have not. [Laughter]

Let me say this. I am just as much interested in the preservation of natural resources as anyone. Anytime you have any, well, complaints, or even ideas, write me a letter. [Laughter]

Of course, I guess I led with my chin on that one. I do not have to ask for ideas from people; but I want you to feel that the door of the Secretary of the Interior is always open. Naturally, I haven't time to talk with all of you, though I would enjoy it; but you may rest assured that we will see that every letter is answered, and every interest given full consideration. Thank you. [Applause]

CHAIRMAN HANNAH: Thank you very much, Mr. Secretary.

CHAIRMAN HANNAH: I presume we are safe in assuming that those who are left are those who are interested in conservation. Those who are interested in politics are those who have departed. [Laughter]

Very properly, the next topic on our program this morning is "The Myth of Idle Resources," to be presented by the head of the Department of Economics at Dartmouth College. It is a great pleasure to present Mr. Hines at this time. Mr. Hines. [Applause]

THE MYTH OF IDLE RESOURCES: A RECONSIDERATION OF THE CONCEPT OF NONUSE IN CONSERVATION

L. G. HINES

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It has become commonplace in both the scientific and popular literature on resources to point out that conservation does not imply nonuse, or idleness, of resources. Carefully interpreted, this doctrine is economically sound, but there is evidence that its uncritical acceptance as a rule of policy may serve to justify antisocial resource allocation and the very antithesis of conservation.

To an alarming degree emphasis upon full use or "full employment" of all resources diverts attention from the important consideration of the type of use that may be appropriate for given resources, and affords a basis for attack upon conservation programs by those who wish to bring all resources under commercial exploitation. In the views of some, all that is required to attain optimum allocation and conservation of resources is a pricing system that functions reasonably well—with market-determined prices directing resources to the areas of greatest need and enforcing conservation of less abundant resources through higher relative prices. The market economy is thought to provide an adequate gauge of human needs as well as an automatic method of satisfying them.

According to others, any concern over the conservation of resources —either renewable or exhaustible—simply demonstrates a sentimental attachment to a movement of a bygone era, or a naive lack of faith in the ingenuity of American scientists. According to the technological enthusiasts, we can confidently rely upon science to provide the solution to resource depletion when the actual need arises. All we need do in the meantime is to make way for the unhampered use of existing resources. Seldom has the questionable aphorism that necessity is the mother of invention been so harmfully misapplied.

THE PRICING SYSTEM AND RESOURCE ALLOCATION

Although the advocates of the *laissez-faire* approach to resource allocation frequently include the most articulate technological enthusiasts, let us look separately at these two views. The American economy has, at least within the past ten years, performed well in producing the goods and services that are generally considered essential to the satisfaction of human needs. But it is an affront to common observation as well as to economic analysis to contend that our market economy, simply through the attainment of full employment, can relieve us of the responsibility of appraising the possible shortcomings of a given resource allocation in relation to human needs. As a first approximation, the market economy does afford an imperfect but usable index of resource worth through the designation of prices, but the pattern of resource allocation that results may fall short of meeting important human needs.

In the first place, the American economy responds to human needs only obliquely. That is, the distribution of foods and services brought about through pricing-system direction of resources is based upon the individual's ability to pay, not upon the number of dependents or the extent, say, of dental deficiencies. Individuals exercise control over resource allocation in direct relationship to their expenditure of purchasing power, and only by disregarding important ethical considerations can the current distribution of income be accepted as a satisfactory guide for all resource allocation. That such considerations cannot be disregarded is shown in the familiar instance where society supplements market direction of resources in education, health, housing, roads, defense preparations, and the like. The description of market resource allocation as a democratic economic voting system, where each consumer casts dollar ballots to determine the direction of production, is a mistaken analogy—at least in terms of the generally accepted meaning of democracy. Only if each consumer had the same number of dollar votes, and hence an equal voice in determining resource use, would the analogy be correct.

Do not, however, mistake the foregoing as a plea for equality in the distribution of income. The significance of income distribution is elaborated at this point only to emphasize that resource utilization depends upon decisions made by members of society, and that there is no reason to assume (1) that the marketing process inevitably satisfies all human needs, or (2) that market decisions are superior to non-market decisions.

Even if one ignores the overriding importance of income distribution upon resource allocation, however, other distortions in the operation of our market economy must be acknowledged. Monopoly elements in our system—on the side of both labor and enterprise—restrict the consumer's authority in the allocation process. At the same time inadequate knowledge may prevent the consumer from consistently reaching decisions that truly express either his interest or that of society. In some instances the consumer may unwittingly provide patronage for the irreversible depletion of resources. An illustration with which you are all familiar is that of the snowy egret, at one time threatened with extinction because of the market for hat plumes.

Institutional and cultural influences may also obstruct the attainment of the socially optimum resource allocation. It is well known that some tenure arrangements encourage exploitative farming, which may maximize short-run gain for the tenant but involve short- and long-run social misuse of resources. On a wider scale, if exploitative farming practices lead to advanced soil deterioration through wind and water erosion, the effects of such socially undesirable practices may extend well beyond the original site of the malpractice. Dust storms and floods are notorious for their disregard of property lines.

Clearly here are problems of social control that cannot be left to the automatic operation of the pricing system. In some cases the necessary remedy, although difficult to accomplish, may be simple to state, such as changing tenure arrangements and increasing the information and skill of the cultivator. In other cases, however, we must recognize that the optimum social use of some resources is commercial idleness. Land areas that yield only sporadic returns during seasons of abnormally favorable rainfall, or during the mining of the original topsoil, should generally be withdrawn from cultivation to reduce both personal hardship and social losses. When commercially idle, these land areas may provide social beenfits, such as watershed protection, sanctuaries for wildlife, and public hunting grounds, that are clearly of greater importance than the intermittent private gains resulting from commercial exploitation.

At the same time that the pricing system fails to restrict commercial utilization of some resources that should remain idle, it provides no effective means by which an individual can express his desire for commercial nonuse of resources. At best the consumer is faced with the ineffectual alternative of abstaining from the purchase of a commodity produced with resources that should remain unexploited. The wilderness area strikingly illustrates this dilemma.

Wilderness—increasingly recognized as a unique antidote to the pace of a highly industrialized civilization—yields social returns that become greater with each increase in population, extension of cultivation, and mechanization of production. Here indeed is a case where no reasonable doubt can be entertained concerning future worth: wilderness will increase in social value, undoubtedly at a progressive rate, as our economy continues to expand. But unfortunately wilderness is one of the most delicate and perishable phases of nature, and in addition the perishability of the wilderness area is almost always irreversible. Once commercial intrusion has blighted the wilderness, decontamination is virtually impossible.

The problems such areas face, fortunately not extending to the irreversible destruction of certain primitive charactistics, are well illustrated by the history of the Quetico-Superior region. This superb canoe country embraces semi-wilderness in Minnesota and near-wilderness in Ontario. But as with most areas of this type, the Quetico-Superior has endured repeated threats to its integrity. The most recent encroachment has come in the form of air-serviced lodges and air-borne fishing expeditions in the Superior Roadless Area of this region—now happily restricted through federal air space control. Note, however, the social inequities and misallocation of resources that occurred when the use of the airplane allowed private land holdings to be brought under commercial exploitation.

Portions of the Superior Roadless Area, which formerly could be reached only after more than a day's canoeing, now were accessible to the affluent fisherman in a matter of minutes, to the great detriment of the physical features of the canoe country as well as the solitude so highly prized by the wilderness canoeist. Even the possible mitigating influence of competition was absent in the development of the lodges. Scattered private holdings permitted each lodge to enjoy, literally, a small island of monopoly as a base for the exploitation of the adjoining public property—with the magnificence of the natural surroundings attracting those who otherwise would surely have been repelled by the unharmonious and shoddy accommodations. Commercial exploitation of resources in the Superior Roadless Area illustrates the failure of the pricing system to recognize the desires of those who not only do not wish to patronize such lodges, but find their presence a discordant barrier to the full enjoyment of the Quetico-Superior.

But the failure of the market economy to provide a socially adequate criterion for resource utilization is by no means confined to non-commercial use. Renewable resources, such as soil, ground and surface water, some wildlife, and timber, may require periodic disuse or idleness to preserve a given level of productivity through time. Failure to allow a sufficient period of idleness to permit such resources to regain or maintain fertility is to obtain an artificially high national output at the expense of the resource base. And although the United States has followed this practice, especially in the case of some renewable resources such as soil, there are certain very definite dangers from such a policy. One reason that conservationists are sometimes dismissed as "calamity howlers" is the failure of their critics to look behind the statistics of national output. In agriculture, for example, output has increased at the same time that our farm population has decreased, which superficially appears to refute the claim for the necessity of conservation. Improved seeds, new pesticides, improved machinery, irrigation, and more intensive cultivation have drastically increased soil yield.

The great danger is of course that the increased yield may at times actually mask the deterioration of the soil, and that unless exploitative practices are checked, a point may be reached where soil rehabilitation will require vast amounts of other resources—labor, fertilizer, capital, and prolonged idleness.

TECHNOLOGICAL INNOVATION AND HUMAN NEEDS

One of the unfortunate by-products of technological innovation is the encouragement of unfounded confidence in the capacity of our resource base to withstand the strain of any emergency requirement, whether it be war or population irruption. Actually, as previously mentioned, although resource yield may be increased by various innovations, depletion may in some cases have reached the stage where the resource base is singularly unresponsive to pressure for increased output.

The technological enthusiasts' proof of the inexhaustibility of resources is based largely upon faith and selected illustrations. This comforting doctrine simply ignores much of the real problem. The brilliance of new scientific discoveries should not blind us to the fact that, even though certain innovations may dramatically increase the yield of some resources, we cannot accurately predict when such achievements will occur. So long as prognosis is so uncertain we must guard against resource depletion that will produce discontinuity in our economy's raw material supply, since for a highly industrialized, interdependent economy the result is necessarily a serious decline in national output.

In this connection, little doubt can be entertained that *eventually* a feasible technical and economic method of beneficiating Lake Superior taconite will provide a major portion of the iron ore requirements for the United States iron and steel industry. But at the present time the answer to the technological enthusiasts has been given by the leaders of the steel industry through the large-scale investment in the development of the Labrador and South American ore fields. Although considerable research is underway in the iron and steel industry in an attempt to develop an economical beneficiation process, the depletion of the Lake Superior high-grade ore supply is a tangible fact that cannot be ignored.

But let us meet the technologists on their strongest ground: What of the case of petroleum, where new techniques of discovery and drilling have consistently added to the supply of this resource? Does this mean that we can ignore the problem of eventual depletion on either the ground that the present rate of discovery will be projected into the future indefinitely or that improvements in petroleum utilization will eliminate any need for husbanding existing supplies? Clearly it does not. We can rejoice in the fact that past predictions of petroleum exhaustion were incorrect, but we should exercise no less care in adjusting present consumption to the most nearly accurate estimates of present and future needs and supplies.

Again, however, the technologists have a reply. We have synthesized rubber; we have produced quinine substitutes; we can transform the abundant coal into thousands of useful commodities. Finally, we have split the atom. In short, by applying enough research talent, capital, and other resources to a given problem its solution generally follows as a matter of course.

Aside from overstating the efficacy of scientific research, this view completely ignores the persistent economic problem that will continue to plague mankind: resources (including time) cannot be lavished upon one project, such as atomic energy, without reducing those available for other undertakings. As a nation we cannot operate at full technological speed in all directions, just as we cannot devote all our resources to the production of aircraft and still have as many battleships as we may need.

Sometimes the technologists adopt a sort of teleological determinism in describing mankind's steady advance upward to a broader resource base. Each period builds upon the resources and knowledge of the past: bronze upon stone, steel upon iron, and so on. The flaw in this oversimplified interpretation of the past and future—other than the pertinent observation that such a happy sequence of events has not always taken place—is that a disregard for the conservation of the resources that are the necessary base for ascending to the higher stage of development violates the essential cornerstone of this very doctrine.

By accepting the technologists' preoccupation with certain exhaustible resources, however, we have neglected an important fallacy. The view that technological innovation invariably retards the rate of resource depletion is simply incorrect. Our resource base is still suffering from the impact of some technological innovations. The steel plow and disk brought rapid destruction to the protective cover of the Great Plains; the development of the donkey engine and the railroad drastically increased the rate of depletion of virgin timber in the United States and at the same time retarded natural renewal by increasing fire hazards and destroying young growth; ground water was quickly depleted in many areas as a result of the perfection of the centrifugal pump and the development of the turbine pump; the development of high explosives and rapid transportation has endangered the survival of the whale and many other fugitive wildlife resources.[1] Finally, at the present time incredibly powerful pesticides produce by-product results that, although largely unknown, are hardly encouraging.

SUMMARY CONCLUSION

Let me summarize my argument by saying that we would be less than prudent if we relied on the alleged omniscience of the market economy or the skill of the technologists to shield us from the very pressing interdependent problems of the present and the future. The needs of mankind cannot be revealed and met within the perimeters of the market economy alone, but require conscious appraisal of social goals and the means of attaining them. High in the scheme of social goals to fulfill basic human needs must be a definite provision for idle resources—idle to permit replenishment of productivity and to provide an emergency buffer for a future that seems more uncertain than ever before.

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DISCUSSION

MR. COLLINGWOOD: We are indebted to Mr. Hines for a very thoughtful and thought-provoking paper. I had an idea, as he touched some of those controversial problems like wilderness areas and petroleum and other natural resources, that we would have a number of questions. Are there any questions?

MR. CHESTER S. WILSON (Department of Conservation, Minnesota): Mr. Chairman, I would like to ask Mr. Hines if history records any instance where scientific or technological discoveries have been applied in time to avert impending human suffering or disaster.

MR. COLLINGWOOD: A very interesting question, Mr. Hines.

MR. HINES: I suppose the simplest answer to that is to say I do not know, and I do not know anyone who could give the answer.

MR. WILSON: I might say I thought that would be the answer to my question. (Laughter)

MR. COLLINGWOOD: I see quite a number of people here who, I am sure, have questions.

I never knew a college professor, especially the dean of a college, who would not ask some very thought-provoking questions. We have Dean Hardy Shirley here, Dean of the College of Forestry in the New York State College of Forestry at Syracuse. Dean Shirley, have you any questions or any comments?

DEAN HARDY L. SHIRLEY (Syracuse University): Mr. Chairman, I want to say that I enjoyed the talk very much; but it certainly does bring before us this very important question of when a resource is idle, and whether we should always feel we must make everything usable all the time.

I have no specific questions proposed; but I do feel that this talk is worthy of our careful study, particularly of our searching of our souls to find out by what means we will guide the use of resources, aside from those we have commonly with us today, particularly that of the market. Thank you.

MR. COLLINGWOOD: If there are no further questions, I will turn the meeting over to the Chairman, with the comment that our train is on schedule, and there is ample time for further discussion of the next two papers. Dr. Hannah.

CHAIRMAN HANNAH: Our next speaker was born in West Virginia, educated at the State Universities of Nebraska and Minnesota, was a country school teacher and a school superintendent, was a member of the faculty at the University of Minnesota and Ohio State University and, for the last 15 years, has been Head Chairman of the Department of Rural Sociology at the University of Missouri.

During his long career, he has often been called upon to collaborate and advise with the U. S. Forest Service, Farm Home Administration and other federal agencies concerned with conservation.

It is a pleasure to present to you Professor Lively, who is going to talk to us on the social side of conservation. (Applause)

THE SOCIAL SIDE OF CONSERVATION—SOME REFLECTIONS ON THE CONSERVATION MOVEMENT

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The conservation movement in the United States is now about 50 years old; and, although it has made unmistakable gains of lasting benefit to the American people, it has not yet become a popular social movement. Furthermore, the outlook suggests that it will probably not become a popular social movement in the sociological sense.[1] Rather it will likely remain as it now is: an educational movement sponsored and promoted primarily by a minority of the *intelligentsia*; by experts in physical and biological science; and by certain nature lovers and farsighted laymen and public agencies concerned with the state of future resources. As such, the movement may spread gradually until its teachings are eventually practiced by most of those who deal directly with our so-called natural resources. Such an achievement will require much time, however, and the movement will doubtless require some assistance from social change and social crises. Also, there is the possibility that the movement could be hastened if more effective methods and techniques of education and promotion were employed.

In view of the importance of the problems of resource use and management, and the amount of scientific knowledge now available on the subject, one may well wonder why the conservation movement has so far failed to become more popular. It is a thesis of this paper that the main reasons are two in number: (1) The concept of conservation has never been adequately understood by the masses, especially by those who should be most concerned, and (2) the people have been insufficiently motivated to do anything very effective about the situation.

In the days when the term, "conservation," meant to use sparingly with little or no waste, the general public may have understood its meaning fairly well. But it was never popular in those terms. Since those days, the concept has acquired new and more subtle meanings and has been applied to many different situations. But the lay public has been unable to divest itself of the earlier connotation. Furthermore, the dictionary, the authority of common resort for the layman, is

[1]A popular social movement, in the sociological sense, exhibits certain rather readily determined characteristics. *First*, a state of social unrest arises in the face of a recognized problem situation; *second*, agitation develops excitement resulting in organized effort to meet and solve the problem quickly. *Third*, as the solution begins to be effective, there is a gradual sobering up and settling down to the task of carrying on. *Fourth*, there is a lengthy period in which the gains are consolidated and built into the institutional structure of the society. The recognized farmers' movements of the past such as the Granger movement, have generally followed this pattern.

not helpful. The result is a confusion that renders the term "conservation" utterly inadequate to convey the current meanings and applications now in vogue among scientists. No smart merchant would think of attempting to sell his product under such a misleading and ambiguous label. Not only are the philosophical aspects of the concept misrepresented; the concrete aspects, the short-time objectives (such as contours, soil building crops, trees as a crop, recovering used resources, etc.), by which the uninitiated grasp something of the significance of the concept in terms they can understand, are so numerous and varied that they often seem unrelated to each other, and, therefore, confusing. Unlike most verbal symbols that readily diffuse throughout the population, the term, "conservation" is generic in nature in that it includes many things not always associated in the common mind.

Furthermore, the concept of conservation is not a stable one. Rapidly advancing sciences concerned with resource use have greatly changed its meaning during the last 50, or even 25 years. Elsewhere,[2] I have suggested that to be effectively transmitted to large numbers of people with a view to changing their attitudes and habits, a concept must not only be elementary and possess clarity of definition, but it must also possess stability. The general concept of conservation does not appear to qualify on any of these counts. A full understanding of the concept of conservation, as now conceived, requires almost the equivalent of a college education. It is difficult to demonstrate except in piecemeal terms, and, when so presented, it tends to lose, in a maze of minor concepts and skills, both comprehension and motivation. In other words, because of inability to sell the notion of conservation *in toto,* we are forced to sell its more concrete aspects separately, often without either full comprehension or any appeal which provides adequate motivation to action.

With respect to motivation it may be stated at the outset that clear recognition of the problem involved, including what, if anything, is to be done about it, is basic to successful educational effort. When dealing with mass movements, even as with individuals, resort to artificial incentives in lieu of comprehension may lead to surprising results not in accord with the planned objectives of the effort. Perfunctory compliance in order to obtain some offered reward may result in warped practices which may defeat, wholly or in part, achievement of the goal for which the effort was stimulated.

There can be little doubt but that large numbers of people, perhaps a majority, feel no compelling need to spend time or effort to do some-

[2] "Some Aspects of the Problem of Forest Conservation." *Journal of Forestry* 50 (3), March 1952, pp. 216-219.

thing about our dwindling natural resources. Farmers on grade A land are still convinced that their soil is inexhaustible. Such farmers are likely to regard many practices which fall under the general head of conservation as a good thing for the other fellow who has been less fortunate in selecting his land. Farm owners on poor land, like farmers everywhere, look at the expense of conservation reforms, and grimly decide to hang on for fear they may lose what little they have if they start experimenting. As for farm tenants, they still think largely in terms of moving to a better farm.

In the matter of wildlife, the farmer who hunts is likely to post his land to keep out intruders, keeping his limited stock of game for himself and his immediate neighbor farmers with whom he practices reciprocity in hunting. During seasons when game is more than average plentiful, he will condone hunting on his land by local villagers of his acquaintance, but he prefers not to take chances with strangers from the city. He is aware that game is less plentiful than formerly, but he is cautious about encouraging its increase lest too much grain and other farm products be consumed or destroyed.

As for the urban population, these people are mostly too preoccupied to be bothered about such questions as conservation; and anyhow, resource exhaustion seems pretty remote and beyond their control. The high market prices of many of the products of field and forest are seldom attributed to resource exhaustion, and the recurring stories about disposing of surplus food products through livestock, storing similar surpluses in caves, and destroying inferior grades of such products in no way suggests approaching famine to the proverbial man on the street. Urban sportsmen of the trophy hunting class merely go a little farther and spend a little more to penetrate those areas where fish and game are still abundant. A few turn to a farmer relative or friend for a bit of hunting. But the bulk of the urban population turns to some recreational substitute, such as a week-end at the lakeside where there is little concern whether or not a fish is caught. Although many exceptions to these generalizations may be noted, it appears that relatively few urban people are yet in the mood to expend much effort, if any, to make more remote the day when they may be denied the products of some resource now being used in abundance. We may well inquire how this can be so, in view of the mass educational effort of the last 25 years.

Perhaps the most serious block in the way of advancing the cause of conservation, in the usual sense, is the existence of a socio-cultural environment that is at best neutral, and at its worst openly antagonistic to the idea of saving resources. This cultural situation is rooted in the history and traditions of our nation. It moulds the attitudes and fixes the habits of virtually everyone who grows up and lives in it. One can scarcely escape its influence from the cradle to the grave; nor do we want to escape it entirely.

The predominant influence of the American socio-cultural environment upon individuals now born and brought up in it is to give them a sense of plenty, even of abundance; to encourage them to spend, to waste, even to destroy. During the more than 300 years since this country was settled by a landless, frugal, hardworking people, the steel plow and the power sawmill have effectively dissipated their traditional attitudes toward the land as a sacred thing animated by spirits to which man must be attuned if he would reap a bountiful harvest. We have not only plundered the continent, but more and more we insist upon rearing our youth in ignorance of the processes of nature and the experience of history. In this matter, we seem to be preparing to ignore or repudiate our earthly origins, though there is little evidence that we shall ever be in a position to divest ourselves of them.[3]

Yet the so-called "rape of the Continent" has often been too darkly painted. It is true that it involved terrific waste and destruction, but there were compensations. It brought a remarkably high material level of living within a comparatively short period of time. It brought a scientific technology which built industrial cities, drained off the surplus rural population, and permitted American farmers to become the greatest producers per man that the world has ever seen. It developed an initiative and self-confidence in the people that has become traditional and, with a bit of nurture, bids fair to prevail for many generations yet to come. But best of all, perhaps, this "plundering" of virgin resources brought rapidly an accumulation of surplus wealth beyond essential needs, some of which was turned to the advancement of science and scientific technology. As a result our scientific technology leads the world. Our research has opened the way to creative science which now fabricates synthetic resources from substances and elements heretofore regarded as either immutable or worthless. In the long run this new-found, creative science may be the determining factor in the survival of our civilization with its high material level of living; for without a technology that locates new supplies of dwindling resources, and new uses for known materials, there can be no possibility of maintaining indefinitely such a civilization. But for this development of science, opening the way for a future civilization based upon human rearrangement of Nature's elements, this nation might

[3]Cf. "A community which ignores or repudiates its origins, in its present acts, is no more whole and healthy than a man who has lost his memory." *Soil and Civilization*, by Edward Hyams. New York: Thames and Hudson, 1952.

have become another Japan, or even India,—overpopulated and underfed.

It is clear, however, that science has not only postponed the day of reckoning for the sins of resource destruction. By inventing techniques to compensate for loss of soil fertility, and by inventing synthetic substitutes, science has prevented the people from feeling the pinch of such scarcities as might have arisen from our declining soil productivity and the growing scarcity of fish and game. And so, with such a display of productivity as has characterized the nation during the past 40 years the traditional notion of conservation gains popularity slowly. Although the habit of resource waste may have declined somewhat among certain groups of producers, a reverse trend seems to have occurred among consumers generally. Certainly no popular social movement for restriction of resource use appears to be in the offing, nor could one be initiated. Obviously, using the conventional doctrine of conservation as the basis for a popular social movement would be greatly simplified if we were less successful as producers; if goods were in scarcer supply; if the people had less faith in the magic of science to produce future miracles of production; if the continued success of American business depended less upon a high rate of consumption instead of hard usage and the early discarding of usable goods for the latest model; and if conspicuous consumption were less valuable as an aid to vertical social mobility.

Our people steadily become more consumption conscious. The growing urbanization and mobility of the population placing greater emphasis upon the consumption of goods and services than upon production capital as a basis for social distinction, the increasing pressures from business and industry to consume and the notion that underconsumption is an important factor in causing depressions, the growing disposition to buy on credit and to live beyond one's income, both individually and collectively, to say nothing of the tragic waste of frequent wars, are all antithetical to the notion of conservation in the restraint of use sense, which is apparently the concept still held by most of the American people. In the meantime, the public utterances of scientific enthusiasts[4] assure us that come what may science can save us. The real question, perhaps, is not *can* science save us, but, rather, *will* science save us. That is to say, in the face of the terrific drain upon currently available resources, will our society support and promote the emphasis upon science that is likely to be necessary to bridge the gap between the present world and the future potential world based upon synthetic resources which now seems to many to be

[4]Bear, Firman E., "We Can Feed a Billion People." *Farm Journal*, April, 1952, pp. 38-40. This would appear to be a splendid example of excessive enthusiasm.

theoretically possible? Or, will the demands of defense measures, added to those of other activities, so rapidly deplete our supplies of known resources that no reasonable scientific effort will be able to bridge the gap between what is and what might be? Science can do many things if given time to pioneer in advance. But science is not at its best in a crisis. If we wait until the fruits of research are needed, it is too late to do the research.

The conservation movement can go on indefinitely, no doubt, and lay claim to many useful achievements; for time and social crisis, both powerful changers of human attitude and habit, are bound to work in its favor. But the movement will not achieve its maximum effectiveness so long as it is identified in the public mind with the attempt to "save" this or that resource. Many scientists, working in the interests of the conservation movement, have made the transition in thinking to a more positive approach, and certain subsidiary movements have been started. For example, there is now a rising interest in growing trees, and in producing wildlife for all sportsmen, as compared to the former disposition merely to protect a shrinking supply. But it is not enough. The forces of conservation should identify themselves more fully with the forces of production, and should exert their efforts to promote the notion of sound scientific management of resources for purposes of efficient and continued production. In other words, sell the essentials of the currently complex conservation concept on their merits as useful economic aids to production, and limit the negative aspects to attempts at controlling gross waste and wanton destruction of resources not now recoverable or substitutible.

The current situation may be such that some will claim this is being done already; while others may claim that the proposal provides for no conservation at all. To this writer, it is a matter of emphasis. One thing seems clear, however. The genius of the American people is not to be found in self-denial, but in production for use; not in saving but in spending and consuming. We are embarked upon an attempt, with the aid of science, to make Nature yield the abundance necessary to support an expanding level of living, and any movement not in harmony with this basic drive is not likely to become popular. But if conservation forces can make a contribution to a fuller realization of this basic drive, and, working from within, effect a better management of resources, they will not only be enthusiastically embraced by the people, but the more purely negative aspects of conservation can be made more effective as well.

But if the above suggestion is adopted, more scientific information must be made progressively available. Hence, our second suggestion is that the advancement of science as related to resources and their use be promoted as never before. The future of our material civilization rests upon our ability to discover new supplies, to devise ways and means of recovering used resources and to learn how to synthesize resource substitutes from hitherto unrecognized sources of supply. Likewise, our civilization rests upon our ability to understand and manage the biological processes of Nature so well that we can produce in abundance the needed types of plant and animal life to provide essential supplies for our population. Even now, our experts are calling for additional supplies of food and fiber; yet we are running behind in the training of scientists and the promotion of scientific research. In the long run, science must be promoted primarily in the interests of human welfare; and to that end, its promotion must be hastened.

Our third suggestion is concerned with public education. It is characteristic of most of the simpler peoples everywhere that they have learned from hard experience the value of the land in their lives. It is the life giver and sustainer, and they show great affection for it. Further, they have developed folk customs embodying their simple knowledge regarding its care and use which carry the force of law. Their folk festivals dramatize these ideas and customs and are effective in educating their youth.

Our European ancestors knew and practiced such customs. They were a part of our American heritage, but we have lost them. In their place we have the attitude of "Nature's insurgent son,"[5] a creature who believes he can despoil Nature with impunity and without penalty. Our people have been fed upon the scientific miracles of the laboratory and the prognostications of scientific enthusiasts to the neglect of the hard facts of Nature's processes. They have swapped faith in Nature for a blind faith in science. Our scientific education for the masses is failing to develop the kind of understanding of Nature that brings respect.

Should we not more effectively teach the truth that, with all of our scientific advancement, Nature is still supreme; that to get best results, man must cooperate with Nature, not fight her; that to cooperate with Nature, to advantage, it is necessary to understand her processes? In the field of agriculture and wildlife, this is fundamental.

The techniques and methods for making such an educational program effective may well merit considerable discussion that would lead far beyond the limits of this paper. But this writer is of the opinion that the thing formerly called "Nature Study," which helped the student to understand the interdependence of Nature's forces and

[5]Lankester, E. Ray, *The Kingdom of Man*. New York: Henry Holt & Co., 1907, pp. 31-32.

processes, and which taught Nature as something to be admired, had much to recommend it as compared to the more recent anthropocentric approach which makes man the supreme agent who transforms Nature at will.

A fourth suggestion is concerned with motivation. We have already suggested that the conservation movement may draw motivating energy from the general drive for production by identifying itself with sound scientific management of resources for efficient and continued production. This will help greatly but it is not enough, particularly in the area of agriculture and wildlife management.

Perhaps one of the most important steps to be taken, where it has not already been accomplished, is to remove the management of conservation programs from politics and place them upon a nonpartisan, educational basis. This is necessary to obtain public confidence.

Beyond that, conservation forces would do well to employ the methods of group and community organization in working with their constituent publics. They should carefully study each group of farmers and sportsmen to learn of its most influential leaders, its deepest interests, and its methods of thought and action. Having determined these, a course of action leading to the ego-involvement of the members of the group can be planned and executed along with, and as a part of, the very essential educational program. The principle of ego-involvement should be employed to the limit. In other words, interest them and help them to help themselves. Do not do things for people unless they do something for themselves that leads toward the same objective. Few people appreciate having services showered upon them, and the practice of paying people to do what they know they should do for themselves is indefensible from a psychological point of view.

The import of these remarks is that the constituent population groups must be involved emotionally as well as intellectually in the processes of sound resource management. The motivation of sheer intellect is not particularly high with most people. But involve them to the extent of a vested interest, and they will defend the cause and slave for it. One of the cardinal reasons for the marked success of the 4-H Club movement is the fact that thousands of farmers and farmers' wives serving as volunteer leaders have made it succeed. In a very real way, it represents their achievement. They have worked for it; they are proud of it; they are sentimental about it; they are ego-involved.

The detailed implications of these remarks, and the techniques necessary for carrying out the suggestions offered, transcend the scope of this paper. If elaborated and effectively applied, however, the conservation movement might profit considerably thereby.

DISCUSSION

MR. COLLINGWOOD: Dr. Lively, you have given us a very stimulating talk, one which challenges some of our old ideas. Apparently, you are rather old-fashioned in some of your ideas when you suggest that we do not do things for people until we are sure they are willing to do something for themselves. That is almost revolutionary.

I wonder if such ideas as this have not stimulated some thought and some questions. I look around here and I see a number of leaders and pioneers in this idea of conservation, men who have grown through the period when conservation was wholly to save, when it went through the period of wise use, and now it has come even further than that.

I am going to try to get somebody to make a plunge. Over here at my left is an old friend of mine, who has gone through a lot of the conservation program and struggle, Benton MacKaye. Many of you know him; many of you have read his works. Benton, haven't you a question or a comment to make which will stir this up?

MR. BENTON MACKAYE: I am afraid not. I would like to have a long talk with Dr. Lively; I do not want to try to bite it all off here. It was a very stimulating talk, but I cannot ask a question in one minute, off the bat like this, which would be fair to anybody.

MR. COLLINGWOOD: Perhaps I put Mr. MacKaye too much at a disadvantage. He says he wants a long talk with Dr. Lively, but not an opportunity just to ask one question in one minute.

Taking another man who lives in the same town with Dr. Lively, who has probably heard some of these comments before, who is stimulated by that same firm soil of Missouri, I am going to ask the State Forester of Missouri, Mr. Howard White, who has gone through a lot of the struggle on conservation, if he has any comments or questions.

MR. WHITE: No, I really have no questions. I am firmly in sympathy with the fine things Dr. Lively has said. Our problem in Missouri, of course, is to try to put them into practice. For my own part, the conflict he has spoken of in our tremendous forest-fire problem in that state—we have made a lot of progress, but we need help by Dr. Lively and forward thinkers of that sort. I thank you very much.

MR. COLLINGWOOD: Thank you, Mr. White. That does not need to stir an answer or a question from Dr. Lively.

I am going to try once more. There is a man here who has done a lot of work on conservation of this same sort and of another sort, conservation of birds and all that pertains to them, one of the great leaders. I want to ask Mr. Baker, of the National Audubon Society, if he has any comments or any questions.

MR. BAKER (National Audubon Society): I have a comment, Mr. Chairman. I think that was one of the finest speeches I have ever heard at any meeting of conservationists. I find myself, I think, in practically total agreement with what he said.

He spoke of the word "conservation." I think we are more and more getting away, Dr. Lively, from using that word a great deal; but we still talk about intelligent treatment and wise use of resources in relation to human progress. It is in relation to the human progress angle which has been neglected generally by conservationists, in my opinion, and it is the essential. If the majority of the population in a democracy is going to influence favorably their legislators and administrators, there needs to be, in my opinion, a reorientation of viewpoint and progress of education among educators, so that the public, in school and in college, gets a comprehension of this which will enable them to act in their self interest.

There is a human-trait obstacle, as I see it; that is a natural tendency of an educator, no matter at what level, to take a greater inerest in the good student than in the poor student, and to reach the majority in a democracy vote; that condition must, I think, be altered. When every educator, professor, assistant professor, superintendent, and principal, curriculum advisor, supervisor, teacher of whatever grade, is able to integrate reasonably this idea with whatever subject he may be teaching, I think we may grow a human crop which will be able to influence intelligently their administrators and legislators. That is a long process, but it is badly needed at the present time.

If I may take a moment to tell a story to illustrate the kind of citizen I.Q. I have in mind, I think it might amuse you. His name was Monroe. He got on a bus; and, when the bus driver called out, "Washington," the man who got off Monroe thought must be a Mr. Washington. When the bus driver called out, "Adams," a man got off who Monroe thought must be a Mr. Adams; and so it was at Jefferson and Madison. When he called, "Monroe," Monroe got up and got off.

A man drove up in a car and shouted at him: "Is this Monroe?" "Why, yes," he said. "Well," said the man in the car, "I am looking for 125."

"My God," said Monroe. He reached in his pocket and gave the man $1.25. (Laughter)

MR. COLLINGWOOD: Dr. Lively, does that stir anything in your mind?

DR. LIVELY: I might say, in connection with that point raised, that we need to raise up another generation properly with the proper attitude; I am in complete accord with that. The only thing I am worried about is that I think we are not doing a very good job of it. I think it is perfectly natural that our teachers are asked, as they are, when teaching a thousand things and trying to develop personality, rather to give students something of a more orthodox method, and teaching a little subject matter and some definite habits instead of just letting them run around and do as they please pretty much, you know.

I think it is perfectly natural that teachers, these days, tend to overplay the miracles of science. Oh, we do it in the universities; we show the students about the miracles of science, without helping them to understand the processes, unless they become graduate students and try to major in it. When we get down to the grades and high schools, it is perfectly natural for the teacher to emphasize the wonderful things which science does and can do, rather than to deal with something which is not more prosaic, but something which they are less equipped to do; namely, to interpret, give a genuine interpretation of the marvels of nature and her processes. I think we could do more of it, somehow or other, all through the educational work of the elementary and high schools.

MR. COLLINGWOOD: Thank you, Dr. Lively.

The brakeman will now turn the train over to the conductor on schedule. Dr. Hannah!

CHAIRMAN HANNAH: Today, when the eyes of all the world are turned toward the funeral which is taking place in Moscow, we can hardly help but be aware of the world wide struggle in which we are engaged, a war, in fact, which can be lost on the battlefield, but may not be won there. Most of us are increasingly appreciative of the fact that there is no alternative but that the United States must be a strong military force. We recognize, however, that the war in which we are engaged is likely to be won or lost in what takes place in those vast areas of the world which are called undeveloped.

There is an increasing recognition of the fact that one of the prime considerations in all those areas is an adequate food supply for the people. Until people have enough to eat, they are easily sold a different political philosophy than the one they have. Anything may be better than chronic famine; any political philosophy which promises something better is worth trying maybe.

This next topic, "Meeting Human Needs," is very important; and the person who is giving it to us is, I think, better able to discuss it than anyone else with whom I am acquainted.

Born in Ohio, educated at Oberlin and Ohio State College and the University of Minnesota, a professor of botany and later head of the department of the University of Puerto Rico, a member of the faculty of the University of Minnesota in plant pathology, head of the department of biology or a professor of biology at the Virginia Polytechnic Institute, head of that department in Washington State College and, for the past ten years, in charge of the very interesting and very productive work of the Rockefeller Foundation in Mexico, in which he has translated what has been done in this country and elsewhere on hybrid corn, genetics in beans and other crops, and has demonstrated that peoples outside the United States can employ scientific knowledge to the great improvement of food production in a very brief period of time, if they are told how.

Very few of us ever have an opportunity to see our work translated into productive usefulness to the degree that our next speaker has; and it is a pleasure to me to introduce—to me, he is more or less of a hero—one who has done more to translate the United States to Latin America, and has done more to inspire others with the possibilities of what can be done in this area, than anyone alive, I believe.

It is a great pleasure for me to present to you the Assistant Director for Agriculture, of the Rockefeller Foundation, Mr. J. G. Harrar. (Applause)

MR. J. G. HARRAR: Mr. Chairman, Ladies and Gentlemen; I would like to say, before I start, that I should perhaps plead guilty to being an optimist about this world in which we live. I am a profound admirer of technology; I have great belief in the powers of social science, and I accept the importance of economics. To show that I am an optimist, I even believe we can get together some day so that perhaps we can interact a little more effectively, a little more efficiently, toward the solutions of those problems which we all recognize exist, which we may see through different types of glasses.

MEETING HUMAN NEEDS THROUGH AGRICULTURE

J. G. HARRAR

Deputy Director, Division of Natural Sciences and Agriculture, the Rockefeller Foundation, New York, New York

Basic human needs include food, health, shelter, education and opportunity, and the most fundamental of these is food. The rapidly increasing population of the world is continually putting greater pressure on agriculture to supply adequate quantities of food for human needs. While agricultural science has made great strides during the past half century, it is being hard put to meet current demands for food, and this demand is increasing daily. Therefore, in an attempt to satisfy growing world food requirements it is necessary to apply all known techniques for agricultural improvement on a wide scale and to develop new techniques and new sources of food production. These two approaches might be termed conventional and non-conventional agriculture.

Conventional agriculture has reached a high degree of development in certain areas of the world, principally in the western hemisphere; but for the world as a whole, there still remains a wide gap between actual and potential levels of food production. Indeed if it were only practical—economically, physically, and in terms of power requirements, for example—to apply to all the arable land of the world the presently known facts of agricultural science, then surely the world's total food supply could be increased by a factor of at least two, and very probably a larger factor. To do this it is not necessary to depend exclusively on bringing new land into production but rather to increase the yields of land already under cultivation to figures approaching the potential production capacity of the soil and crop plants. Present average world yields of basic food crops are pitifully low, and these could be greatly increased by the application of known techniques. These include more efficient utilization of available water as well as more efficient measures for making water available, soil improvement and conservation, use of appropriate varieties of crop plants, the application of organic and inorganic fertilizers, the establishment of rotation systems, and the control of devastating pests and diseases. Mechanization is of great importance when feasible. The more strictly technical improvements, moreover, must be supplemented and supplanted by correlated improvements in storage and transportation of foodstuffs and in land-holding systems.

If agriculture is to be improved throughout the world, then agricultural science will have to be placed on a truly international basis. Each area of the world will have to exchange material, information, and personnel with other areas for mutual gain. A large share of the burden must necessarily fall on the U. S. A. However, certain social problems must be met if international agriculture is to succeed. These include cultural and language differences, in addition to those of race, creed, color, and tradition. Before agricultural science can become truly internationalized these differences must be rendered unimportant, and an atmosphere of mutual understanding and respect established. If this can be accomplished, then it may be expected that world food production through conventional agriculture will substantially increase with resultant improvement in world economy and harmony.

Efforts in this direction are already being made by certain worldwide agencies, such as UNESCO, government agencies, such as the TCA activities under U. S. auspices, and philanthropic organizations such as the major U. S. foundations. The sum of these efforts can have great and useful impact in increasing world food production and will undoubtedly do so if care is exercised in the selection of personnel and if there is adequate and stable support to permit maximum accomplishment.

Although the improvement of conventional agriculture on an international scale holds great promise in the solution of current food problems, it is unrealistic to assume that such a program will alone solve food production problems of the future. Of course it is essential that mankind take a rational attitude towards both basic aspects of the food population problem, and begin to do something to curb the continuous and rapid increase in the numbers of persons who are doomed to be hungry and miserable. A discussion of population control is outside the limits of this paper. But it is within the present topic to emphasize that food production by present conventional methods always involves the process of transformation of solar energy into food through the medium of plant metabolism. This is an uneconomic and time-consuming procedure, and is extremely inefficient in terms of the ratio of available solar energy to the ultimate food energy product. Therefore, it is essential that a continuing and increasing effort be placed on researches leading to production of vitally increased quantities of food by what are presently non-conventional methods. Certain of these may be described as follows:

One form of unconventional agriculture which should become rapidly transformed into a phase of conventional agriculture is the utilization of marine resources for food through management. Marine resources today are essentially limited to those which can be blindly captured; and, with rare exceptions, little effort has been made to gain sufficient understanding of the sea as a great organic entity which can be made to produce diverse types of human food in great quantity and these regularly harvested. The great potentiality of the sea for producing food plants is little understood and has not been exploited; neither has marine biology been developed to a point at which techniques for the increased concentration of plant and animal products can be economically applied. It is generally agreed that the sea offers one of the greatest convenient sources of additional food supplies for the world, and unquestionably greater and greater emphasis will be placed on the rational utilization of this almost inexhaustible source of direct or indirect human food.

The problems of marine resources are too complicated to be summarized accurately in one or two simple figures. But it is worth remembering that some seven-tenths of this planet on which we live is covered by water. And this figure is not as illuminating and impressive as it should be. For the more important fact relates to the over-all conversion of solar energy, through the photosynthetic process, to stored chemical forms which are potentially available to man as food. And here the ultimate argument for the sea is a much stronger one. For several times—perhaps as much as ten times—as much photosynthesis goes on in the sea as is carried out by plants on land.

There are also great possibilities for food production through the mass culture of microorganisms, but to date little progress has been made in this direction. It is well known that certain algae and fungi are important sources of vitamins and other elements of great significance to the human diet. It is also known that certain microorganisms multiply with almost incredible rapidity and under certain optimum conditions can produce greater tonnage of dry matter per unit area than ordinary food plants.

Therefore, it is desirable that greater emphasis be placed upon research on food-producing potentialities of microorganisms with the object of developing techniques for their mass production and subsequent utilization.

Weather still remains an agricultural enigma and an agricultural handicap; and in most of the areas of the world the farmers have to be content with minimum quantities of natural rainfall at the times when water is needed for normal crop production. Probably greater annual losses result from the irregularity of rainfall than from any other factor. One solution of this problem has been the increased use of irrigation water; but this, of course, has definite limitations. We certainly do not understand, as yet, the factors which combine to produce the phenomenon which we recognize as weather. It is true that there have been attempts to induce rainfall with varying degrees of success, but these attempts have been limited by our very partial understanding of cloud physics. It is conceivable that with an increasing body of knowledge of the atmosphere and its components, it may be possible eventually to influence the distribution of rainfall to produce a much more effective pattern.

Since water is of paramount importance in nearly all forms of agriculture, and since sources of fresh water are not only limited but are being depleted rapidly in many parts of the world, the possibility of the economic conversion of sea water into fresh water, or at least into water of low salt content suitable for agricultural purposes, is of major importance. If this could be accomplished at energy costs which would be economically feasible, then there would become available an unlimited source of agricultural water which could be transported great distances for irrigation purposes.

The direct transformation of solar energy into food offers enormous possibilities for the solution of food production problems in the future. As stated before, no matter how efficient conventional agriculture may become through research, it is still true that the transformation of solar energy into food through the medium of crop plants is a highly inefficient process. Therefore, as the mechanism of photosynthesis becomes more clearly understood, it may very probably be possible in the future to utilize solar energy directly for the transformation of inorganic substances into metabolically useful organic compounds. If this were possible, the quantities of food produced by conventional methods would doubtless be supplemented by, and conceivably largely replaced by, those quantities resulting from direct utilization of energy from the sun.

Finally, utilization of sources of energy other than solar may be brought into play in the years to come. Thus, it is conceivable that nuclear energy may supplant that now derived from conversion of fuel into heat or conversion of water power into electrical energy for domestic purposes. Heat, light, and power for agricultural purposes should become cheaper. Fixation of atmospheric nitrogen would be much less costly with a resulting decrease in the price of fertilizer. Farm machinery costs would be reduced and farm products would be transported more cheaply. The possibilities here are necessarily vague and uncertain at the moment since security issues conceal the knowledge of known uranium resources, as well as the possibility of recovering energy from other nuclear reactions.

In conclusion, there may be a question whether Malthus and others of his fraternity were too pessimistic in their dire predictions concerning the ultimate effects of population pressures on food resources. If conditions which they knew were to remain unchanged, their conclusions might be reasonably accurate. However, advancing technology should begin to enable mankind first to supplement and eventually to supplant a very large sector of conventional agriculture by new techniques which will produce very much larger quantities of food than had been believed possible. This should also result in significant reduction in the number of individuals engaged in agricultural production and free them for other constructive tasks of importance to mankind.

DISCUSSION

MR. COLLINGWOOD: Dr. Harrar, you have kept a fine meeting with a remarkable address. We are deeply indebted to you for this broad scope which you have given to this whole problem of conservation of natural resources, and our responsibilities as leaders in this sort of work.

Are there any questions? If not, I will turn the meeting back to the Chairman, Dr. Hannah.

CHAIRMAN HANNAH: Ladies and Gentlemen, we are very grateful, first of all, to all our speakers who participated here this morning; and to you for your patience. The meeting is off to a good start.

GENERAL SESSIONS

Tuesday Afternoon—March 10

Chairman: HARDY L. SHIRLEY
State University of New York; Dean, College of Forestry at Syracuse University, New York

Vice-Chairman: WATERS S. DAVIS, JR.
President, National Association of Soil Conservation Districts, League City, Texas

TRENDS IN LAND AND WATER USE

INTRODUCTORY REMARKS

HARDY L. SHIRLEY

The topic for this afternoon's discussion is "Trends in Land and Water Use." This subject is of a special interest to us today, as we are changing from one administration which has been in power in our country for a long while to another. It is well, at this time, that we consider the importance of land and water use as it has been influenced by many factors in the past.

One which is of a special importance is the question of tenure, who owns the land, and for how long they have owned it. This question of land tenure has caused the rise of civilizations and governments, and, where ill-adjusted to man's needs, it has caused their downfall. Many of the freedoms which we enjoy in America today were won by our ancestors in England against the feudal lords in disputes over the use of the land and the application of human labor to the land; and, conversely, failure to win such disputes in other lands, notably in Russia, has made possible a transition from human subservience to an aristocratic land-owning class, and from human subservience to a master state.

Our own country numbers among its early colonists those who sought freedom from economic shackles which tied them to other men's lands and other men's factories. Land was not offered free to all comers in colonial days, not until the passage of the Homestead Act in 1862 did free land become generally available. But acquisition of land by private holders was easy from the beginning.

Ownership in fee simple, especially in a pioneer country, makes wasteful use of lands and its resources. Unchecked by social restraint it leads to the loss of fertility, and destruction of the soil which supports life. Man too is degraded, and ultimately destroyed, in this process.

Restrictions on ownership, on the other hand, tend not only to discourage initiative, but to promote special privilege, monopoly, loss of human freedom, and strife.

Our task in the United States, as in all civilized lands, is to open the door widely for those creative individuals who develop practices which enhance land productivity, while we place a restraining hand on those who would reduce it to a desert waste.

We must follow a middle course between permitting privilege and permitting irreparable loss. The trends in land use in our country today are not the result of unilateral action by government, by landowners, or by society in general; rather, they are the products of the interaction of these three forces.

It is our privilege this afternoon to hear representatives of each discuss the issues which determine these trends.

Our first speaker this afternoon is responsible for forest lands, both national forests and, in an advisory capacity, for other forest lands as well. Together, these make up almost one-third the total land area of our country; and they provide products which lead to the employment of about four per cent of our total labor force.

Our first speaker is the Chief of the United States Forest Service, a man with rich experience and education in research, in administration, and in land management in public service. I have pleasure in presenting Dr. Richard McArdle. (Applause).

MULTIPLE USE—MULTIPLE BENEFITS

RICHARD E. MCARDLE
Chief, Forest Service, U. S. Department of Agriculture, Washington, D. C.

Last week a young lady asked me what we do in management of the national forests. I said that we satisfy some of the people most of the time and most of the people some of the time, but always try to consider the interests of all the people all of the time. I believe I only confused her, but my jesting reply got me to thinking again about the many different groups of people who use the national forests—people who rightly feel that they have a proprietary interest in these great public properties. Every citizen of this country owns a share of stock in the national forests—one share only, no less and no more. But that one share is immensely valuable. It is becoming more valuable with every passing day.

The national forests are unique public properties—distinctive not only because they encompass 181 million acres of timber and range, jutting mountain peaks, and uncounted lakes and streams, but more particularly because of the management objectives applied in their administration. Most public lands are managed primarily for a single purpose, or in some instances for a dual purpose. The national forests are managed for many purposes.

Today, more than at any time in the past, this concept of multiple-use management is being challenged. I do not recall seeing the challenge thrown down exactly as I have phrased it. But it can be seen none the less plainly in proposals to dedicate, legislatively or otherwise, large areas to one use or for the benefit of only one group of users. It can be seen in proposals to remove large areas from public ownership so as to benefit primarily one use or one group of users. It is evident in other proposals that would give this or that group exclusive or dominant rights in the use of these public lands.

A development such as this is inevitable in the growth of our country. We need to recognize the existence of this rapidly changing public-land use situation and to be aware of its implications. We need to look as far and as clearly into the future as we possibly can. This is no penny-ante game; the stakes are tremendous.

In the management of the national forests, we of the Forest Service are having to face up to this problem every day, in more places and in more and more different ways. This is particularly true of the western national forests. Here are former hinterlands that only a few years ago were remote and inaccessible. Here are areas whose values have jumped as population has increased, as industrial and agricultural development has leaped ahead, as transportation and communication advances have erased barriers of space and time. The ever-increasing intensity of use of these national-forest lands brings conflicts that at times seem nearly impossible to resolve satisfactorily. Yet resolve them we must, for only by wise balancing of these diverse interests can these public properties be made to yield maximum benefit to all our people.

To help you see this picture more clearly, let me sketch for you some of the multiple uses of the national forests that by leaps and bounds are growing in volume and intensity.

Take fishing and hunting, for example. More than 2 million hunters and some 4 million fishermen used the national forests last year. We are wholeheartedly in favor of this use of the national forests and want to see it increase.

As a matter of fact, all kinds of recreational uses of the national forests are on the increase. Last year the national forests had 30 million recreational visitors. Ten years ago there were only 10 million. Some of these millions of people want only a place to picnic. Others want to camp overnight. Some want summer homes. A lot of people just want to put a pack on their backs and hike up and down hill. Some want to experience the fascination and deep-seated satisfaction that comes with penetration of a vast wilderness far from sight and sound of civilization. And recently national-forest winter sports use has been increasing at an almost unbelievable rate. The present need for ski runs and lifts and so on is something we failed to foresee a quarter of a century ago. It make me wonder if today we are seeing future recreational needs accurately—even for only 10 or 20 years ahead.

At any rate, with better roads and more of them, with better automobiles and more of them, with a 5-day week, longer vacations and more leisure time generally—whatever the reasons may be—more and more and still more people are using the national forests for recreational purposes. That's fine. We like it.

And we are not alone in approving this use of the national forests. Measured in terms of dollars spent, outdoor recreation is one of the biggest businesses in this country. Think of the people who make some or all of their living by selling food and lodging, souvenirs and soft drinks, fishing tackle, golf clubs, gasoline, and a thousand and one other items to recreationists. Think of the many others employed in manufacturing these articles or in transporting recreationists here and there or in serving them in countless other ways. The national forests produce a big chunk of this business.

But to me the commercial aspects of national-forest recreation are secondary to the opportunity for people to get away from the mental and emotional strains of present-day living. It is a safety valve which has great significance in keeping people healthy and happy—in helping them to keep a balance and a sense of values in a world increasingly beset with emotional strain. You can't put a dollar sign on this sort of thing, but we believe it is one of the great contributions the national forests make to the people who own them.

Now let's consider for a moment a quite different use of these same lands. More than half a century ago the Congress set forth, as a principal objective in establishing the national forests, the need to furnish "a continuous supply of timber for the use and necessities of citizens of the United States." For a great many years this use, like recreational use, was not very large. Today, as with recreational use, the picture has changed. The amount of timber cut on the national forests has doubled in less than 10 years. Receipts from the sale of timber were $64 million last year and will be even larger this year.

Harvesting national-forest timber under the sustained-yield principle has helped stabilize communities and local industries and has provided jobs for many thousands of people—not only in the wood-using industries but for butchers, bakers, doctors, lawyers, and merchants serving these industries and their employees. Local governments benefit too because 25 per cent of all national-forest reecipts go to the States for roads and schools in the counties having national-forest land.

We think this use of the national forests is all to the good. It's good for our country—for all of us. It's wise use of land. It's something that we want to see increase and prosper.

There is still another substantial use of the national forests. Last year permits were issued to about 20,000 ranchers to graze some 3 million sheep and nearly a million and a quarter cattle and horses. Grazing fees total about $5 million a year, and this income, too, is shared with the States and counties.

This dollar income, however, does not tell the whole story. Much national-forest range is high-mountain summer range, usable for only part of the year. The home ranches of many livestock owners are at lower elevations with only winter range. We try to work with these stockmen to fit the private and public range together so as to provide the year-around operation required for this industry. We believe that livestock grazing is a proper use of many national-forest areas. Let no one tell you that we want to fence out grazing use of the national forests. By building up the grazing capacity of these ranges through reseeding and good management we can improve their value. We already have demonstrated that this can be done. We want to make this use play an even stronger part in our whole agricultural and industrial economy.

There is another use of the national forests which in many respects is more important, more essential, than perhaps any other use. The basic legislation establishing these public forests provided, as a principal reason for their reservation in public ownership, the need to make certain of "favorable conditions of water flows." Our pioneer forefathers knew how important water is. It was the first thing they looked for when they selected a homesite or a place to establish a new community. As time passed, their children and great grandchildren hired other people to worry about their water supplies. It became a job for the superintendent of the city water works, not for the apartment dweller, the individual home or factory owner.

But today, we are again becoming aware—as individual citizens—of our water situation. In the past six months I have been in three cities where water use temporarily was being restricted. I was in another city when the reserve supply of water was sufficient for only a few hours of use. There are towns, both East and West, where further industrial expansion depends on somehow finding an increase in current water supplies. Most of you know about the great distances to which some cities are now reaching out for more adequate supplies of water—distances that only a relatively few years ago would have been considered incredible and probably impossible. These are not things that might happen; these are actualities.

No one knows precisely how much the national forests—and other public lands—are worth to the people of this country as major sources of clean, pure, usable water. I have seen estimates by competent authorities that, at current water prices, add up to hundreds of millions of dollars a year. I know of some national-forest watersheds that for water yield alone are estimated to be worth $2,000 an acre.

Dollar value alone is a poor criterion. Water is something that we must have; it is worth whatever we have to pay to get it. There are other ways to measure the value of this use of the national forests. There are more than 1,800 communities — some are cities of several hundred thousand population—that are dependent on national-forest watersheds for their domestic and industrial water. Thousands more are partly dependent on the national forests. Many—I believe I could say most—of the major irrigated farm developments of the West depend on national forests for their water supplies. More than 600 hydroelectric power developments—including practically all of the major power projects in western states—depend on water from the national forests.

But valuable as our national forests are today for water production —valuable as these lands are today—it's small compared with the role they are going to play in years to come. If we want water tomorrow we must take care of our watersheds today.

Well, perhaps that's enough to show you that the national forests are lands of many uses—and many users. The intensity of all these uses is increasing—and increasing rapidly.

As intensity of use increases we sometimes find one or more of these uses in conflict. It would be more accurate to say that there is conflict between the personal interests of the various groups of users. The wilderness enthusiasts, and there are many of them, naturally want timber cutting and other commercial uses excluded on substantial areas. Timber users object to taking too much commercial-quality timber off the market. The argument, of course, turns on how much is too much. Hunters want more wild game, but the livestock people say that too much big game takes forage away from domestic livestock. Again, we come up against how much is too much? Irrigated land farmers and other water users are beginning to protest vigorously any use of national-forest watersheds that may jeopardize their water supplies.

There are conflicts, too, between surface and subsurface uses. Development of the mineral resources of the national forests is legitimate, proper, and in the public interest. But it should be done with minimum disturbance of surface resources.

I guess it all boils down to this: The practical workability of the multiple-use concept of national-forest administration is being tested on a scale and to an intensity greater than anything we have ever experienced. The Forest Service believes that many of the diverse uses of the national forests are reasonably compatible. If we had to deal with only one group of users, I suppose it would be somewhat easier to agree on a reasonable course of action. But we must consider the interests of all the people. So we usually find ourselves in the middle.

Let me make it completely clear that I think being in the middle is exactly where we ought to be. I believe that our inability to completely satisfy each and every group of national-forest users is a definite sign of success in doing the job assigned to us. When each group is somewhat dissatisfied, it's a pretty good sign that no one group is getting more than its fair share.

The guiding principle laid down for us nearly 50 years ago still hits the mark. I think you know it. We were instructed to so administer these national forests that they would yield the "most productive use for the permanent good of the whole people, and not for the temporary benefit of individuals or companies"; and "where conflicting interests must be reconciled, the question will always be decided from the standpoint of the greatest good of the greatest number in the long run.'' That is still the guiding policy of the Forest Service, and I hope it always will be. It expresses the responsibility that we have to protect and build up not only your share of stock in these national forests but that of every one of your 150 million fellow Americans.

COMPETITION FOR PUBLIC LANDS

HUGH B. WOODWARD

Attorney-at-Law; President, New Mexico Game Protective Association, Albuquerque, New Mexico

The history of mankind is a story of competition for land. Human greed for control of favorably situated land areas, from earliest time, has been the principal cause of war and conquest.

Before the first Spanish explorer set foot on the American continent, Indian tribes fought for control of choice hunting grounds.

It was the white man's pressure, crowding ever westward, which provoked the bloody Indian wars, ended only when decimated tribes had been finally and completely conquered and confined upon reservations generally established upon lands least desirable to the ever expanding population of newcomers.

The so-called range wars which marked the settlement of the western states originated in conflicts between stockmen for control of grazing on public lands. The bitter fights between sheepmen and cattlemen were contests for use of rich pasturage.

The coming of the homesteader was bitterly resented and resisted by both sheepman and cattleman.

Some thirty-five years ago, as a youthful District Attorney, in a district comprising the four northeastern counties of New Mexico, I found that most criminal cases then originated from quarrels between the so-called ''nesters'' and the livestock man who had for years used the lands upon which the settlers sought to establish homes.

In the western states, before the advent of the homesteader, the unwritten code of livestock men was that control of watering places established a primary right upon those public lands adjacent to water which could be grazed therefrom.

In the '70's and '80's when the lieu land law was in force and script could be bought on the open market, which would permit the holder to acquire title to public land by selection and make payment in script, the earliest patents, almost without exception, covered those tracts which had living water.

When the lieu land law was repealed and script was no longer available, the early homesteads were nearly always established with the purpose of getting title to land controlling water.

Throughout the West, among stockmen, the practice was early adopted of having an employee, sheep herder or cowboy, file a homestead entry on spring or creek, help such employee in proving up, and then purchasing title for a small consideration.

In examining abstracts of title to lands in northeastern New Mexico and northwestern Oklahoma, I found that in some instances, by the use of script, early patents had been obtained for long series of 40-acre tracts adjoining corner to corner. The sheepman who owned the ranches told me that the land had been thus selected to form a barrier which would protect interior lands from homestead settlement.

My first experiences as a prosecutor had to do principally with crimes of violence, ranging from the cutting of fences, maiming, poisoning and shooting of cattle to gun fights and homicides growing out of intense feuds between homesteaders and stockman.

The law of New Mexico was the law of the open range. Cattle and sheep had primary right of use until such time as the homesteader had protected his field by what was termed a "legal fence." Under the law's definition, such fence must conform to standards which put its erection far beyond the financial reach of the newcoming settler.

The homesteaders' flimsy fences did not keep out range cattle. Growing crops were devoured and devastated over night. The outraged settler frequently defended his fields with rifile or shotgun against such invasion.

Cattlemen charged, frequently with much truth, that the newcomers lived upon butchered beef.

The settlers charged, probably with like truth, that cattle herds were pushed into the vicinity of fields with the express purpose of destroying crops.

In numerous instances prospective settlers were terrorized and frightened by livestockmen and their employees.

It was only after the enactment by Congress of criminal statutes for the protection of homesteaders that studied interference with settlers abated.[1]

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[1]Act of February 25, 1885, c. 149, Sections 1, 2 and 3, 23 Stat. 322. Title 43, Sections 1061, 1062, 1063 and 1064 USCA. R. S. Sec. 5508; (Act of Mar. 4, 1909) c. 321. Sec. 19, 35 Stat. 1892. Title 18, Sec. 51, USCA.

Interpreting the Act of 1885, a California Federal Court, in an early case, said:

"This Act is intended to prevent the inclosure and appropriation of tracts of public land by associations of cattle owners, who have surrounded by fences public lands and excluded settlers. . . ."

Of the section making it a felony to obstruct entry upon public lands by threats or intimidation, the Federal Court in Nevada in 1912 said:

"It (the Act) is intended to prevent obstructing any person from peaceably entering on or settling on the public domain as well as to permit free passage or transit over or through public lands."

I vividly recall a case in which my client was a cattleman, a big two-fisted fellow, born and raised on the plains, far from schools, who had acquired his ranch through years of toil and struggle. When a homesteader moved in upon a piece of choice land in the middle of his pasture, with one of his cowboys the rancher rode up in the night and advised the newcomer in no uncertain terms that if he valued his health and the health of his family he would be gone on the following day. The frightened settler followed this advice. But the evictor had been recognized. A complaint was filed with the United States Attorney, the defendant promptly arrested, prosecuted, and sentenced to serve a year at Leavenworth.

His sojourn was during the time when Dr. Frederick Cook, of Arctic fame, and other oil and stock promoters, together with a sprinkling of bankers who had run afoul of the federal laws, were likewise sojourning at Leavenworth.

My client, upon his return, hunted me up to tell me that he had never been in such high-class company; that most of the prisoners at Leavenworth were stock brokers and bankers.

To those of you interested in the historical study of the struggle for the protection of public lands and particularly the forested lands of the West, I recommend the reading of Gifford Pinchot's book, *Breaking New Ground.* It is a fascinating story of the terrific struggle extending over many years between early conservation-minded and public-spirited citizens on one side, bitterly opposed by private mining interests, private lumber and timber interests, private power interests. and stockmen's interests.

The movement to transfer forest reserves from the Department of Interior to the Department of Agriculture and to establish the United States Forest Service finally enlisted strong support from President Theodore Roosevelt.

In his message to Congress on December 2, 1901, Mr. Roosevelt strongly urged the need for conservation of forests and waters, stressing the economic values particularly to the western states.

Despite the President's strong support, the struggle to establish the Forest Service continued until February 1, 1905, at which time the Congress enacted H. R. 8640, the Transfer Act, which established the Forest Service and transferred responsibility from the Department of the Interior to the Department of Agriculture.

Gifford Pinchot became the first Forester.

James Wilson was Secretary of Agriculture. In his letter, addressed to the Forester, dated in March, 1905, after quoting the Transfer Act, the Secretary in part said:

"In the administration of the forest reserves it must be clearly borne in mind that all land is to be devoted to its most productive use for the permanent good of the whole people, and not for the temporary benefit of individuals or companies. . . .

"The continued prosperity of the agricultural, lumbering, mining, and livestock interests is directly dependent upon a permanent and accessible supply of water, wood, and forage, as well as upon the present and future use of their resources under business-like regulations, enforced with promptness, effectiveness, and common sense. . . . and where conflicting interests must be reconciled the question will always be decided from the standpoint of the greatest good of the greatest number in the long run."

The establishment of the Forest Service and its adoption of rules and regulations brought even more intense opposition from western Congressmen and Senators.

In 1907, President Roosevelt declared:

"The opposition of the servants of the special interests in Congress to the Forest Service had become strongly developed, and more time appeared to be spent upon it during the passage of the appropriation bills than on all other Government bureaus put together."

In his book, Pinchot states:

"Quite literally, the Service had to fight for its life. Without constant vigilance, without the generous and effective help of Eastern Senators like Spooner and Beveridge, and above all without the militant backing of T. R., we could not have lasted through a single session of Congress. In both House and Senate it was the men who were free from the pressure of Western interests, men from states that contained no National Forests, who saved our 'bacon.' "

Further on Pinchot relates the extreme difficulty encountered in overcoming the resistance of livestock men grazing herds and flocks on western forests to all measures of regulation and control and their violent opposition to the payment of any compensation for the privilege of grazing upon forest lands.

Almost fifty years have passed. During all of these years certain leaders of the livestock interests have continued to fight the Forest Service, bitterly condemning its administrators, its regulations and the enforcement of such regulations.

These spokesmen do not represent all western livestock men nor all Forest Service permittees, by any means. Many western ranchers recognize the need for Forest Service regulations and support its policies of administration.

In the western states public lands may be classified thus:

First: National Parks and Monuments;

Second: Indian Lands;

Third: Military reserves and withdrawals;

Fourth: Public Domain Lands;

Fifth: Forest Service Lands;

Sixth: State lands ceded to the several states by the Federal Government for the support of state institutions.

Limited time does not permit discussion of all classes of public lands. Suffice it to say that as to Public Domain and State lands, in most western states, the livestock industry has obtained dominant control and tenure which have eliminated most competition.[2]

The Forest Service lands have been administered in accordance with Secretary Wilson's letter for the ultimate good of all of the people and not for the immediate benefit of livestock men or timber operators.

It is the Forest Service lands for which private interests grasp, seeking either to acquire title to such lands or to gain unrestricted and unregulated privileges thereon.

The larger livestock operators who graze their animals upon the national forests are the group most vocal and militant in their demands, although in some states timber interests cast covetous eyes upon lumber resources.

The chorus of denunciation and criticism of Forest Service administration, arising from a handful of livestock permittees, has always been, and is now, continuous and loud. Yet in relation to other users and beneficiaries of the national forests: recreationists, tourists, most lumbermen, farmers, and those who benefit from the water supplies sustained by conservative administration of the high water-yielding areas, these livestock permittees are but a small fraction of our citizens who benefit from conservative forest administration policies.

[2]For comparison of efficient management of Forest Service lands with loss of control of Public Domain by BLM, see the Yale Law Journal, March 1951.

New Mexico is a typical western public lands state. It contains about 7 million acres of Indian lands, 14 million acres of Public Domain, 9 million acres of Forest Service lands, 12 million acres of State lands, and considerable areas in military reserves.

The Forest Service records show that in New Mexico 1,785 permittees paid grazing fees for the privilege of grazing upon national forest lands 77,150 head of cattle and horses.

One hundred and sixty-eight permittees paid for the privilege of grazing 103,876 head of sheep and goats.

A total of 1,953 permittees enjoyed by reason of their permits special rights and privileges upon the national forests of New Mexico not accorded to some 160 million citizens of the United States who own the forests.

These figures do not tell the whole story. We find that of the 1,785 permittees grazing cattle and horses, 1,384 mostly Spanish-American farmers, holding permits to graze from one to 40 head of cattle and horses, grazed 13,987 head.

Four hundred and one permittees enjoyed the privilege of grazing 63,163 head of cattle and horses.

The 1,384 owners of small permits, which is 77.5 per cent of the total number of permittees, enjoyed only 18.1 per cent of the grazing privileges.

One hundred and eighty-nine permits were issued for the grazing of 101 or more head of cattle and horses. These 189 permittees, which is 10.6 per cent of the total permittees, enjoyed 63.9 per cent of the grazing privileges.

Of the 168 permits granted for the grazing of sheep and goats, 152 permittees, grazing less than 1,000 head, enjoyed 59.8 per cent of the privileges.

Sixteen permittees, grazing 1,000 or more sheep and goats, enjoyed 40.2 per cent of the privileges.

Two of these 16 enjoyed 16.9 per cent of the privileges.

A total of 181,026 domestic animals were lawfully upon the United States Forests in New Mexico in 1950.

For these special privileges, the permittees paid $338,633.00.

Despite the clamor of the livestock associations that permittees enjoy neither tenure nor stability in their operations, a grazing permit upon the national forest is recognized throughout the West as a valuable financial asset. Upon sales of ranches involving grazing permits on the forests, prices are fixed not upon patented lands and improvements alone but upon the basis of the grazing capacity of the entire ranch.

Let me illustrate:

The New Mexico Game Department about a year ago bought the Heart Bar Ranch situated in the middle of the Gila National Forest. There were about 800 acres of patented lands with considerable improvements. The total price paid was $134,000.00. Of this, the appraised value of patented land and improvements was $34,000.00. The Department paid $100,000.00 in cash for the grazing privileges upon the national forest held by the owners, which permit carried grazing rights for between 500 and 600 head of cattle.

This is a fair example of what I am saying.

What about the recreational values of the national forests of New Mexico?

In the last fiscal year 163,636 citizens of the United States bought hunting and fishing licenses and paid to the State of New Mexico for the privilege of hunting and fishing and recreating, $749,288.

In other words, for every dollar paid to the Federal Government for grazing rights upon national forests in our state, hunters and fishermen paid $2.21 to the State Government for the privilege of recreating, principally upon national forests. Because most of our trout streams open to the public are upon the national forests and the major portion of our big game areas open to the public are upon the national forests, these hunters and fishermen cherish and highly value their privileges.

As against the $338,633.00 paid for grazing fees by Forest Service permittees, New Mexico spent during the last year $193,000 inviting tourists to recreate in our mountains and along our streams.

The State Tourist Bureau estimates the economic value of the tourist trade at 150 million dollars a year.

The number of permittees who graze herds upon the national forests does not increase as does the number of hunters, fishermen, and recreationists.

A total of 181,026 domestic animals graze upon the national forests of New Mexico. If the number of hunters and fishermen increases as such number has increased in late years, by 1956 there will be a licensed hunter or fisherman in New Mexico for every cow, every horse, every sheep, and every goat pastured upon forest lands.

The same pattern I have outlined for New Mexico in ratios of domestic livestock, numbers of permittees upon Forest Service lands, and numbers of hunters, fishermen and recreationists maintains throughout the other western states (Table 1).

In New Mexico there are almost 100 hunters and fishermen who enjoy recreational privileges upon the national forests, for every livestock permittee.

The 1952 report of the Chief of the Forest Service shows that in 1951 the Forest Service issued a total of 19,708 pay permits to livestock operators for the grazing of livestock on all national forest ranges.

In the same year the national forests received 30 million recreational visits, which was a 9 per cent increase over 1950 use and a 66 per cent increase over 1941, the year of highest pre-war use.

For every livestock permittee using national forest range for grazing, 1,521 American citizens used the national forests for recreational purposes.

There is pending in the Congress of the United States a bill to permit the Forest Service to expend a part of its revenue to improve and expand overtaxed recreational facilities upon national forests.

The Congress has before it a bill to permit the spending of a part of grazing receipts for the improvement of range and grass lands upon the forests. *We* endorse such legislation. But the American National Livestock Association and many State Livestock Associations are opposing another pending bill authorizing expeditures of Forest Service funds for recreational improvements or facilities.

If all the paying livestock permittees on national forest lands, 19,078 in number, unanimously opposed such expenditure, which they do not, the Congress must consider whether the interest of the 19,078 permittees or the interest of 30 million recreational users is entitled to greater consideration.

The life of many western towns depends upon the harvesting on a sustained yield basis of timber from national forests and the processing of logs into lumber and allied products. Orderly cutting of Forest Service timber is a principal objective of the Service.

More important than grazing privileges, more important than timber cutting, more important than recreational privileges, more important than wildlife, is the necessity of protecting our high water-yielding areas within the national forests of the West in order to assure the teeming millions who live in the valleys below their water supply.

I have attended many conferences concerning water rights, flood control, irrigation, and water use in the western states. I have heard learned papers and discussions dealing with the siltation of valleys and dams, the danger of floods, the value of dams in flood control and generating power, the number of acre feet of water available for use, the allocations of water between states, between districts, between users, the productive capacity of different types of land for fruits and agricultural products, and the need of water for increasing industrial and municipal uses.

TABLE 1. ELEVEN WESTERN PUBLIC LANDS STATES
COMPARISON OF NUMBERS OF GRAZING PERMITTEES WITH NUMBERS OF HUNTERS AND FISHERMEN; AND INCOME TO FEDERAL GOVERNMENT FROM GRAZING FEES WITH INCOME TO STATES FROM HUNTING AND FISHING LICENSES.

11 National Forest Grazing States	Paid Number Permits		Number Animals Grazed		Total Licensed Fishermen Hunters	Total H&F License Fees Paid	Total Grazing Fee Paid By 6 Western Regions Embracing Eleven Western States	
	C & H	S & G	C & H	S & G				
Arizona	825	26	137,278	86,224	158,302	$ 689,962	R1	$ 591.944
California	1,236	86	105,896	121,599	1,550,153	5,517,453	....	
Colorado	1,801	521	155,753	606,599	483,509	2,890,594	R2	1,078,578
Idaho	1,952	382	109,266	608,016	411,579	1,169,136	....	
Montana	1,691	164	115,051	256,321	324,525	1,027,666	R3	1,006,931
Nevada	273	45	54,772	128,546	77,043	635,000	....	
New Mexico	1,761	163	79,336	93,949	163,636	749,288	R4	1,566,241
Oregon	858	108	70,044	149,751	263,129	2,011,074	....	
Utah	3,330	751	107,431	482,241	264,405	881,900	R5	373,709
Washington	454	29	18,892	39,965	498,709	2,386,697	....	
Wyoming	1,004	237	106,642	427,824	236,615	1,655,763	R6	381,709
TOTAL	15,185	2,512	1,060,361	3,001,035	4,431,605	$19,614,533	Total	$4,999,112
	17,697		4,061,396					

In these conferences but little reference is made or consideration given to the conservation and protection of the high water-yielding areas in the national forests from which the waters of the western states derive.

As pointed out by Theodore Roosevelt fifty years ago, water is the life blood of western civilization.

In the southwestern states water tables, without exception, have been and now are falling. Underground reservoirs utilized for agriculture by pumping are being depleted more rapidly than replenished.

The problem of sufficient water confronts every western state, every agricultural area, every municipality and every industry. Only by the most conservative and careful control of the watershed areas can we hope to maintain and advance the agricultural and economic life of the West.

Uncontrolled grazing of high mountain slopes develops progressive erosion, lessens the water retaining and retarding capacity of the mountains and results in disastrous floods and progressive siltation of our dams, which store the water so vital for municipal, industrial, and agricultural needs.

The critics and opponents of the Forest Service propose the return of public lands to private ownership, or the cession of public lands to the States, or the annulment of the power of the Forest Service to regulate and control Forest Service land use.

The history of private ownership of forests in the United States has been, generally speaking, a tale of exploitation and destruction. Limited numbers of our major corporations engaged in timber and lumber production have learned and have the financial strength to operate their timber as a crop and not as a mine.

Only a very few private owners have either the financial resources, the foresight, or the will to permit such system of management.

Adverse economic conditions frequently compel private owners and operators of timber lands to follow practices which they know are wasteful, improper and unsound.

The record of the western states' administration of the lands ceded to them by the Federal Government is, generally speaking, a record of waste, mismanagement, lack of planning and control, failure of continuity of policy and domination by private interests looking to their immediate financial benefit rather than to the future welfare of our whole citizenry.

Every year the United States Forest Service is compelled to prosecute many trespass cases not only against livestock permittees on the forests but against trespassers who would graze upon forest lands domestic livestock without permit.

I have the record of the number of trespass cases prosecuted upon the national forests of New Mexico during the past five years. These cases against permittees average 58 a year.

The cases of violation by non-permittee livestock growers average in number 135 a year, an average total of 193 cases a year.

If regulation and control by the Forest Service is eliminated and livestock growers are permitted to utilize ranges without restraint, progressive deterioration from overuse is as certain as that the day will follow the night.

Some leaders of the livestock industry, complaining of Forest Service regulations, bitterly criticize the tolerance of big game animals, which to some extent compete with domestic animals for sustenance upon forest lands.

Certainly game herds must be limited and managed as domestic livestock herds upon national forests must be limited and managed.

Many livestock operators on the forests value our wildlife resources. Those advocating the policy of removal of game animals stress the importance of meat production. We admit such importance.

Far more important, we believe, is the production of sane, healthful and law-abiding citizens.

The greatest teacher of all times said to his disciples:

"Man shall not live by bread alone."

Lately the proponents of the return of public lands to private ownership have enlisted a new champion. He is president of the Occidental Life Insurance Company of North Carolina and president of the Chamber of Commerce of the United States.

In several recent speeches which have gained national publicity, he has espoused the cause and advanced the arguments of western livestock leaders. His theme is the urgent need to return public lands to private ownership; to eliminate the bureaucratic control of the administrators of the national forests. He is an able and successful businessman, a fluent and forceful advocate.

Knowing that he is the president of the United States Chamber of Commerce, the American public should know some additional facts:

He is a stockholder, director and vice-president of the Fernandez Company, a New Mexico corporation, which corporation is one of the larger livestock growers of sheep and cattle in the Southwest. The Fernandez Company operates not only on patented land but upon national forest lands and other public lands. He is the brother of the president of the Fernandez Company, who for 23 years has been president of the New Mexico Wool Growers Association and who during those years has earned the reputation of being the most outspoken critic and implacable foe of the Forest Service among all western livestock men.

Reading these recent speeches, I recalled the statement of the blind Patriach Isaac:

"The voice is Jacob's voice but the hands are the hands of Esau."

If the members of the United States Chamber of Commerce had lived as I have lived in the states of Colorado and New Mexico for the last forty years and were acquainted with the soil and water problems of the West, as I have observed them, I am doubtful that a majority of those businessmen would support Mr. Lee's announced position.[3]

Overpopulation, shortages of food, fiber, forage and forest products for the hungry millions of Asia and parts of Europe induced overuse and misuse of soil and forest resources with resultant major depletion of productive capacity.

Hunger and want are the strongest weapons of communism. The world today faces problems and crises for which there seems no solution. Its greatest problem is the problem of overpopulation by the human species.

If we are to keep America strong, if the free world is to survive, we must conserve by all proper means our renewable resources. One important part of such a program is retention of the public land of the United States and particularly our forest lands in federal ownership under the management of impartial trained and experienced administrators.

A very wise man many years ago wrote in the book of Proverbs:

"Where there is no vision, the people perish."

You whom I address know the conservation story. Upon you rests the burden of bringing to all the people the true facts. They must decide whether we shall follow the credo of the Forest Service, whether competition for public lands shall be decided for "the greatest good of the greatest number in the long run," or whether it shall be decided for the greatest good of the fewest number for the immediate future.

The cause of conservation is a noble cause. The battle is not for self but for the welfare of our fellow citizens, a battle to preserve for unborn millions the more abundant life we enjoy. It is a battle to keep a free world, a battle to perpetuate our way of life, a battle in defense of these United States of America.

Tell to all the American people the truth about conservation. Keep

[3]Mr. Lee was replaced as president of the Chamber of Commerce of the United States at its annual meeting in April, 1953 (Editor).

on telling that truth from Maine to California, and from Washington to Florida.

We must neither falter nor despair.

If we shall keep the faith, there can be no question about the ultimate decision.

SUMMARY

For every paying grazing permittee upon the national forests in the eleven wetsern public lands states, there were 229 hunters and fishermen seeking recreational privileges on the national forests.

For every cow, every horse, every sheep and every goat grazing under paid permit upon the national forests there were 1.09 hunters and fishermen enjoying recreational privileges thereon.

For every dollar paid to the Federal Government for grazing fees in the eleven western public lands states, hunters and fishermen paid to the several state governments $3.92 for hunting and fishing licenses, i.e., recreational privileges upon the national forests.[4]

DISCUSSION

CHAIRMAN SHIRLEY: Thank you, Mr. Woodward, for that very spirited address. We will now have a little time for questions to Dr. McArdle and Mr. Woodward. Are there questions?

DR. HUGH BENNETT (Virginia): I used to be in the Soil Conservation Service. (Applause) I feel like I am still in it. I want to ask you just two simple questions.

First, I want to compliment Dr. McArdle on his wonderful talk; I agree with it. But I do want to ask him if it probably would not do a little more good if he would put in a little additional explanation to the common people. He uses the phrase "multiple use." That is a good phrase, but the common people do not know what it means anymore than they know what the profit motive means. They do not know a darn thing about the profit motive. They know what profit is, but, when you add the word "motive" on it, they do not know.

What I really want to ask is, while he talks about these multiple uses, if it would not be a good idea to say what the gentleman from Albuquerque has just said, something about using a land according to the way nature made it, to quit using these steep lands, which are too steep for cultivation and have already caused the downfall in a sense, of these lands for any immediate use for cultivation, fine forest lands. Why shouldn't we talk more about using these lands for forests rather than cultivated crops, grow on them where the slope exceeds, in some parts of the country, even ten per cent, in other parts of the country, 12, 13, 14, 15 per cent, according to the capability of the land. Use the land properly.

Then I want to ask the gentleman who has just made this wonderful talk if he has any objection to my saying that it is the best conservation talk which has been made in the last 15 years, probably. (Applause)

CHAIRMAN SHIRLEY: Well, thank you, Dr. Bennett. I do not believe these questions are very hard to answer; I believe you meant them more in the form of instructions from an old master, rather than as questions which expected a pupil to answer.

Are there other questions?

MR. JOSEPH PENFOLD (Izaak Walton League): I would like to ask Mr. Woodward a couple of questions.

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[4]Statistical data compiled by Hugh B. Woodward from statistics furnished by the United States Forest Service and the various state game departments.

First of all, would you elaborate just a little more on the question, "Do grazing permits on the national forests have a commercial volume?" Secondly, because this is much kicked around, does the Forest Service invariably make a livestock cut when a permit is transferred from one rancher to another? Thirdly, what effect do you think the prior prazing right which the livestock operators are demanding, as proposed in their proposed bill, would have on other forest uses, such as wildlife and recreation?

MR. WOODWARD: First, everybody who lives in the western states knows that forest permits, as I said, are valuable financial assets. The going commercial price of a permit to graze a cow upon the national forest during the past five years has varied from two hundred to three hundred dollars.

Now, when they tell you they have no tenure, that is not so, because I know; and I have represented many ranchers, so I know they put the price on the grazing permit and the Forest Service honors the transfer. That is that.

Number two, that is the question of tenure, the tenure of cuts.

We hear a great deal of hullabaloo in every meeting of livestock men about the terrible oppression by the cuts in the number of animals grazed; transfer cuts, they call them.

There is not nearly as much to that as they would have you believe. If the range has been properly used, and is in condition where it will sustain the number of cattle or sheep then being grazed thereon, there is no cut.

Let me illustrate. The Ontario ranch, which is one of the larger ranches in southwestern New Mexico, was recently sold out of a family which had had it for three generations. They talk about lack of tenure. (Laughter)

They had control for grazing of 200 square miles of forest land. Because those ranges had not been overused, the entire permit in the deal—and the deal involved three-quarters of a million dollars—was transferred without the cut of a single sheep, a single horse, or a single head of cattle.

You want to know what will happen if this land bill goes through, which the livestock men propose.

What they want is tenure, sure tenure, and escape from the control and management of the Forest Service. Number one.

Second, they want a vested right upon the forest attached as appurtenant to the patented lands which the livestock man might own, so that, when he sells that base land, the permit will automatically go with it.

In other words, what they say—and they can sugar-coat it all they like—there are two things they demand: First, a sure tenure; and probably, as they do with the BLM land, the committee of livestock men to say whether they are using it properly, not the Forest Service.

Second, a vested right to the permit made appurtenant to the patented land which the permittee may own. And, when they accomplish that, the livestock interests will not have a coordinated use upon the national forests. They will have a dominant and paramount right, superior to other rights.

Does that answer your question?

MR. PENFOLD: Very well. (Applause)

MR. CHESTER S. WILSON (Minnesota): That question which was just discussed is of very great interest to conservationists all over the country. It was a very lively discussion at the meeting of International Fish and Game Commissioners held here this morning. It seems to me this matter which has just been discussed divides itself into two separate propositions; and I would like to ask whether, from the conservation standpoint, there would be any objection to giving a greater security of tenure to the stock raisers, which they apparently enjoy already from what you have just said, Mr. Woodward, to a considerable degree, provided the Forest Service retains effective control over the number of stock which can be grazed, to keep that in line with the condition of the range.

MR. WOODWARD: That is exactly the situation which exists today, and they do not like it. They get a tenure permit and, frequently, the Forest Service does not cut when they should, even though the range is deteriorating. Thy wait, many times for years, until there is a death in the family and the ranch is divided, or until it is sold; then, because it imposes no additional hardship upon the new owner, they do make some cuts.

The situation you suggest is exactly as it is now; what the livestock men want to escape is what they say is a green college kid coming out there and telling them how many cattle or how many sheep a range will graze. They say: "I have lived here all my life, and I know how many it will graze; I know more than these range-management experts, so-called."

MR. WILLIAM VOIGT (Izaak Walton League): I want to put Mr. McArdle on a small spot for a moment.

First of all, I would like to ask if there has been any more or less positive, shall we say, follow-up on the part of the new administration of that public-land planning in the Republican platform. Have they put the heat on you, in other words? (Laughter)

MR. WOODWARD: That is General Hurley's plan, and he got whipped in New Mexico.

DR. MCARDLE: Bill, up until now, there has not been any.

MR. VOIGT: Good!

One more question; that is this. Immediately following Secretary McKay's talk yesterday in this hotel, there was a press conference with him; and, at the conclusion of that press conference, a question was asked by one of the outdoor writers, as to the Interior Department's attitude toward this proposal for an act. I think my recollection is clear that the answer was that the Interior Department, insofar as it had studied the present form of the bill, found no serious objection to it.

Has there been any official position stated by the Department of Agriculture with regard to that proposal for an act?

DR. MCARDLE: It is being studied in the Secretary's office now; and, so far as I am aware, as of last Friday, though I have not checked this week, no official position has been taken. I had the assurance of the Secretary and the Assistant Secretary that no position will be taken until it is thoroughly studied.

Is that what you had in mind?

MR. VOIGT: Thank you.

DRAINAGE AND SUBSIDY PAYMENTS

R. L. DUSHINSKE

Publisher, Devil's Lake Journal, *and President, North Dakota Wildlife Federation, Devil's Lake, North Dakota*

During recent years there has been a growing realization among conservationists that another crime is being committed in the name of progress. Man's grasping desire for wealth, and his need for more lands to raise food to feed a growing nation, are slowly but surely causing serious inroads into wildlife habitat. This is particularly true with regard to the breeding and nesting grounds of waterfowl and other wet-land species.

From the Atlantic to the Pacific coast, from the gulf to the pothole regions of the Dakotas and Canada the story is the same. Ducks and geese are steadily losing their homes as more and more swamplands are drained and water sent into streams and rivers to rush away to the sea.

Much of this is being done with the blessing and financial assistance of the government, the same government which is charged with the responsibility of protecting all our natural resources. Through subsidies, farmers, many of the corporate variety, are encouraged to initiate or participate in drainage programs to make more acres available for crops. Far too often, these drainage programs are money-losing deals—uneconomic projects which the taxpayers collectively are forced to subsidize, but which no business man or farmer in his right mind would undertake with his own money. Seldom have the wildlife values been considered when computing the values of drainage.

The question of wetlands or drainage is not just one of concern to sportsmen. The welfare and use of wetlands—the potholes, the lakes, the coastal marshes—are the concern of all the people. For these are natural resources that are often overlooked in the desire to expand the croplands.

Water, itself, is a precious resource which we have no business tampering with unless we are very, very certain what we are doing. No one knows for certain just what effect this program of continued drainage is having on the underground water table. There are good reasons to believe it is a part of the process by which Americans seem determined to turn their rich country into another Sahara.

We do know that, in many regions of the nation, the water table is sinking dangerously. The very future of whole cities and vast industrial developments is threatened. Yet blithely we go on subsidizing drainage of marginal lands that won't produce enough to pay for the project once drained—and in the process destroying wildlife and recreational opportunities and perhaps water resources worth far more than the skimpy and irregular agricultural harvests will ever return.

Sure, we need to increase food production. But you can take almost any run-down farm in the country and by a program of soil conservation, fertilizing, and good management, increase the production of that farm from 25 per cent to 100 per cent without adding one acre of new land. Here is a generalization, but a sound one: *As of now we don't need the land being gained by many of these drainage projects.* Former Secretary of Agriculture, Brannan, said himself, only a few weeks ago, that most of the increase in crop production during the past few years was the result of improved farming practices rather than increased acreage.

Just what are we trying to do? Buy a few votes for the next election? Or are we stupidly sowing the seeds of desolation?

Naturally, we must always remember that some drainage is essential to our expanding economy. Conservationists have no quarrel with the changes that are necessary to the nation's economy. We insist, however, that there is no necessity for converting land to marginal use, and that wildlife habitat and other uses have their proper place in the evaluation of any wet areas.

There are numerous cases throughout the nation, as well as in the breeding ground of Canada, where wildlife benefits have been shoved out of the picture.

Let's just review a few of the cases:

Down in Florida we find one of the horrible examples. Drainage of the Everglades was started in 1912 and miles and miles of canal were dug to carry off the water. But canals were insufficient to carry the flood waters, peat soil was spoiled by oxidation and brackish waters found their way into domestic underground water supplies.

The United States Corps of Army Engineers had to reverse themselves in an attempt to correct the situation. Now they are developing a series of large pools to hold water on the marsh as a help to prevent vast fires, control floods and compensate for drought.

Further along the gulf coast in Louisiana is one of the most important wintering areas for migratory waterfowl. Among the important areas are the marshes of Cameron Parish, an ideal habitat of furbearers, alligators, fish and other wildlife. This and other areas of Louisiana and Texas have been adversely affected by the conflict between agricultural interests and wildlife conservation.

In the coastal areas, 87 million acres are already in organized drainage districts. Another 49 million acres have been affected by unorganized drainage enterprises in the United States, according to the United States Fish and Wildlife Service.

Another danger zone for waterfowl is the Klamath Basin of California and Oregon where wildlife refuges were established after reclamation had made its selection. Official estimates say that 19 million waterfowl travel down the Pacific Flyway and at least 90 per cent stop over in the Klamath basin refuges each year. During the period of visitation, an estimated three million may be found at any one time on these refuges. It's strange that man must have every last acre of even the most questionable land for his use at the expense of valuable natural resources that belong to all the people.

Now let us move into the central area of the United States where the potholes of the Missouri basin produce more waterfowl than the rest of the nation put together. Conservationists know that the present rate of drainage threatens complete extinction of these prime breeding grounds.

Field and Stream magazine sounded a warning in the publication of "Good-bye Potholes" in 1949. It was the story of Day County, South Dakota, where potholes conservatively average 20 per square mile. At that time the drainage program had accounted for 1,400 of the 20,000 potholes in the county. It was a prime example of what was going on over 5,000 square miles of the best pothole country in the eastern Dakotas.

In recent years, South Dakota has water areas capable of providing breeding habitat for an estimtaed 325,000 to 400,000 pairs of ducks. An average of three young per pair gives an estimate of 1,000,000 ducks produced annually.

South Dakota Game and Fish Director, Elmer Peterson, in his report to the North American Wildlife Conference last year, placed a value of 2½ million dollars on the 400,000 ducks harvested annually in South Dakota, not considering the South Dakota-produced ducks taken in other states down the flyway.

At that time, Director Peterson said, studies showed an annual loss of seven per cent of the pothole area in the study area. He said drainage increased from 1944 to 1947 and remained fairly constant from 1947 to 1950 with 2,000 to 2,500 farms participating. He figured that, from 1946 to 1950, at least 10,700 potholes were wiped out under the subsidized program, and habitat for an equal number of ducks is gone forever.

While these figures do not include just potholes but are figured as agricultural acreages benefited, here are the totals given by the Soil Conservation Service for drainage in the past three years in South

Dakota: In 1949, the total was 30,603 acres; in 1950, it was 26,283 acres; and in 1951, the total was 17,145 acres. The progressive decrease looks heartening, but may be attributed to the fact that the easiest potholes to drain went first.

Assistant South Dakota State Conservationist of the S.C.S. A. L. Ford said this decrease is due ''in no small part to the fact that our farm planners have been discouraging the practice on grounds that migratory waterfowl does and should have its definite place in the over-all proper land use pattern.'' He adds ''Obviously this involves an educational campaign among the farmers and land owners which at best is rather a slow process.'' It is good to hear this indication that wildlife is getting some recognition, and I do want to give credit to the Soil Conservation Service for having changed its policy directives in this regard. Unfortunately, the PMA, which pays the subsidies, apparently haven't read the directives.

Minnesota has been particularly hard hit by damaging drainage practices, losing an estimated 16 per cent of the pothole area of the important western section of the state. Farther north in Manitoba, the Wildlife Management Institute reports that the Canadian government is seriously considering the drainage of 152,000 acres of Manitoba's chief duck producing area. That area in Manitoba produces 70 per cent of its ducks and geese.

Duck production has practically disappeared from the intensive farming in Iowa.

In a current series of articles in the Minneapolis *Sunday Tribune*, Outdoor Writer Jack Connor is doing a service to sportsmen and other conservationists in publicizing a series of drainage projects that are ill-conceived and promoted without seeking the advice of those concerned with wildlife and its values.

Jack Connor painted this dreary picture: The U. S. Fish and Wildlife Service ''made a study of 22 west central Minnesota counties, the so-called prairie-pothole duck breeding area, and found 16 per cent of their small water areas had been drained between 1945 and 1950. In the years 1940 and 1950 alone more than 32,000 small potholes were drained in the Dakotas and Minnesota. The fish and wildlife service estimates that about one-third of Minnesota's waterfowl breeding area has been lost.

''In Iowa the waterfowl breeding area already is lost completely. There are no potholes in Iowa left to drain. By the '30s individual landowners there had completed the job.''

''Karl Danielson, former Minnesota state president of the Izaak Walton League, recently complained to the secretary of agriculture that 'at the rate we are draining wildlife habitat now, there will be no waterfowl left in the next 20 years.' "

Of course, some of this drainage has resulted in the production of good farm land. But too much drainage is unwise and uneconomical.

The Fish and Wildlife Service has pointed out that when government costs are added to the cost to the farmer, the total expenditure for drainage is much greater than the value of the land recovered in many cases.

Drainage that is profitable can and will be done by the farmer. He has a right to improve his farm for his own benefit. But the conservationist can't see why our taxpayers must be burdened to promote the very thing which is destroying our national waterfowl resources.

In North Dakota, too little has been said of the effects of drainage on wildlife habitat. But there are signs of an awakening.

Our state claims to be the nation's top "duck factory." Our Pittman-Robertson chief, Roy Bach, puts a production figure of five million ducks per year on our lakes, sloughs and potholes. He then divides them as a million breeders and four milion young per year.

Of importance particularly to the sportsmen of the Central Flyway is the fact that North Dakota hunters shoot only about a half-million ducks per year or one-tenth of the production. The rest are going down the flyway as a North Dakota export.

What affects North Dakota water areas should be of concern to every sportsman but we who live in the state must recognize the primary responsibility.

The North Dakota office of the Production and Marketing Administration estimates that drainage ditches constructed through 1951 have drained or benefited approximately 1,050,000 acres. This is equal to an area slightly less than the area of Cass County in the Red River Valley.

Much of this drainage has been in the valley, which is not considered a top-flight waterfowl area because of the intense farming, and in the eastern half of the state. Conservationists are fortunate that a wide area extending through the central section of the state has hundreds of potholes nestling between hills of the Coteau range which are not economically feasible to drain.

The western area of the state, west of the Missouri River, is another type of country. It is an area of the "Badlands" and range lands which has never been a heavy waterfowl production area. However, the soil conservation program is giving an assist in this region where thousands of dams for stock watering have been contructed. Unfortunately, most of the new ponds are in the western part of the state, while the destruction of natural waterfowl habitat is in the eastern part where we've had the biggest production.

The PMA reports that 15,402 new water areas have been created by the stock dams. They estimated that approximately $1,000,000 had been paid out in North Dakota for each of the two practices—drainage and reservoir construction.

Roy Bach, Pittman-Robertson director in North Dakota, said "Farm ponds are materially adding to the game production in the west river area of North Dakota."

A complaint registered by A. L. Ford, assistant S.C.S. conservationist of South Dakota, was: "Our farm planners have long been hampered because of lack of a reliable and understandable method by which the migratory waterfowl potential of pothole areas can be accurately evaluated. This is badly needed in connection with accurate determinations of proper land use for such areas. That is, whether the area should or should not be drained because of its migratory waterfowl potential. The U. S. Fish and Wildlife Service agrees with us on this matter. We understand that agency is working on an understandable and usable means by which the wildlife potential of such areas can be quickly and accurately determined."

The Soil Conservation Service has adopted this policy: "The basic physical objective of soil conservation activities by Department agencies shall be the use of each acre of agricultural land within its capabilities and the treatment of each acre of agricultural land in accordance with its needs for protection and improvement."

The S.C.S. Field Memorandum 1120 stated: "The Service, when assisting in drainage, will include recommendations for proper safeguards for wildlife and other resources."

In a further explanation of drainage practices, the S.C.S. reviewed figures in 1950 that "less than one per cent of the total drainage reported could conceivably affect waterfowl habitat. A total of 4,629,784 acres of farmland had been drained by farmers and ranchers at that time. Of this total only 39,648 acres were in swamp, marsh or open water, only part of which was useful waterfowl habitat. In no region did the percentage exceed 1.8 per cent."

The S.C.S., I feel, has shown a desire to cooperate with the wildlife conservationists. Their habitat planting program, which we of the North Dakota Wildlife Federation are doing our best to help promote, is an indication of that.

Any consideration of steps to reach a solution, then, should begin with top level conferences. If representatives of the conservation associations and all the federal and state agencies concerned could sit around a table, certainly some common policy should be forthcoming.

In his recent policy address at St. Paul, Minn., Secretary of Agriculture Benson served notice on farmers that they must depend more upon themselves than upon government subsidies in the future. Certainly he should lend a sympathetic ear to demands that subsidies for drainage be eliminated and that the Department of Agriculture and the Department of Interior cooperate in an "objective appraisal of various values of the wetlands of the nation."

On the state and local level, much can be done to combat promiscuous drainage. Opposition to swamp drainage as injuring wild waterfowl and depleting hunting areas was so strong in Minnesota that the Minnesota Association of Soil Conservation Districts voted at their 1952 meeting in St. Cloud, Minn., to withhold technical assistance to owners of poor lands until the Department of Conservation has had an opportunity to buy the land for wildlife development.

In North Dakota, the Pittman-Robertson Division, in 1948, undertook a sampling survey to designate the best waterfowl areas. Briefly, the main types were: (A) Water areas of greatest stability (having not dried up during the time of man's settlement in the state); (B) Water areas which normally hold water the year round; (C) Transient water areas which hold water for a few days or weeks during the spring runoff or after flash floods, and (E) Man-made areas.

The survey estimated one million water holding depressions in the state divided as follows: A — 4,000; B — 20,000; C — 220,000; D — 750,000; and E—20,000.

About 85 per cent of the ducks produced in North Dakota are raised in the "C" areas which normally dry up during July and August. During periods of more than normal rainfall, such as occurred in the 10 years preceding 1952, many of these areas have carried water throughout the entire summer. These also are highly susceptible to drainage in many areas.

Such a classification system should be helpful in determining what areas could be drained without damaging wildlife.

Certainly there is a challenge for local wildlife groups in the drainage threat. They can do much to advance a program of education among the farmers to discourage uneconomical and damaging drainage. A similar educational program is working in the habitat development program in North Dakota.

There are possibilities, too, in programs to purchase or lease areas to preserve the waterlands for wildlife habitat. This is being done in Minnesota. Designation of these areas as public hunting grounds should meet with popular acceptance.

In conclusion these are the facts to remember:

Coastal areas, prairie potholes and regions throughout the nation are showing the effects of drainage in the decline in duck populations. Every flyway has its vital problems in loss of habitat. In the Upper Midwest, the state of Iowa is virtually without pothole habitat, Minnesota and the Dakotas are losing water areas totalling 16 per cent of the total. In the coastal areas, 87 million acres are in organized drainage districts and 47 million acres of drained land is in unorganized districts. The crying need is for a basic policy which can only be outlined and approved at high level conferences of all agencies concerned with conservation and including the Secretaries of Agriculture and Interior. All agencies connected with conservation must coordinate their thinking and policy pertaining to wetlands. Remember, there may be more valuable resources involved than either farm land or wildlife.

First and foremost, as endorsed and requested by leading wildlife conservation organizations, subsidies for drainage must be stopped. Adoption of a hard and fast classification system with full regard for wildlife production and breeding grounds must be completed and followed in detail when considering any future drainage project.

Every organization, on national, state and local levels, should cooperate in an educational program to bring the need for protection and promotion of wildlife habitat home to all citizens.

As the committee of wildlife conservation planning of the International Association af Game, Fish and Conservation Commissioners said in its report to the Dallas, Texas, convention in 1952:

"It is fundamental that all groups recognize that conservation is the management of all natural resources on a sustained yield basis for the greatest good of the greatest number of people for an indefinite period of time. Conservation means the dedication of those resources to the maximum public benefit, and the elimination of all wasteful and destructive exploitation. It is a state of harmony between man and the land. When both managers and users of all natural resources comprehend that principle, and live in harmony with it, then—and only then—will conservation come of age."

DISCUSSION

CHAIRMAN SHIRLEY: Thank you, Mr. Dushinske.

Inasmuch as our next paper, likewise, deals with agricultural problems, we will defer the discussion of it until after Dr. Salter's paper has been given.

Our fourth speaker is a soil scientist, noted for his research on crops and nutrition. He has made a distinguished career as an agricultural scientist and administrator. As chief of the Soil Conservation Service, he is never an alarmist; nor is he satisfied with any other than the most intelligent possible use of our most important of all resources, the soil.

It is a pleasure to present Dr. Robert Salter, who will speak on "Our Soil Conservation Objectives." Dr. Salter!

WILDLIFE AND OUR SOIL CONSERVATION OBJECTIVES

ROBERT M. SALTER

Chief, Soil Conservation Service, U. S. Department of Agriculture, Washington, D. C.

I have been looking forward to this meeting with you who are the leaders of wildlife conservation. We have a common purpose as wildlife conservationists and soil conservationists. It is to our mutual interest to examine some of the specific objectives that bring us together.

As wildlife conservationists, you are working to maintain and improve the production of game and fish as a natural resource important to the national interest and welfare. As soil conservationists, we are concerned with improving and maintaining the productivity of the land—for food, timber and wildlife alike—to the maximum public and private benefit.

Wildlife is a product of the soil, trees, grass and grain. Since wildlife exists over most of the land area in the country, it is an important agricultural crop. The technologies we use in management of our farm and ranch lands inevitably have a major bearing upon the size and quality of this wildlife crop.

Since the same land that produces our food supports the major part of our wildlife, we are continually faced with the problem of fitting wildlife practices in with the management of the land for food production. Solution of the problem calls for practical understanding and cooperation by all concerned, on or off the land—farmers and sportsmen, wildlife conservationists and soil conservationists.

As I see it, the job we are up against is for all of us together to do everything we can to foster appreciation and production of wildlife by all those who manage our lands, at the same time being realistic in recognizing the practical economic facts involved in primary agricultural production. This can be done, I sincerely believe, without halting progress in drainage, flood prevention, or other land management measures essential for food and fiber production. And it can be done without wantonly sacrificing our game, furbearers, wildfowl and fish life. There *is* a sound middle ground.

The way we have used and managed our lands and waters in the past unquestionably has had a great deal to do with shaping today's wildlife populations. How we manage our soil and water resources from this time on is sure to have an even greater impact on our future wildlife, regardless of regulated seasons, bag limits and other controls of the game harvest. We cannot hope to provide anything like the desired abundance of game for a constantly growing population unless we *produce* more game. And we cannot produce more wildlife unless we manage our land resources so as to provide the necessary food and cover for wildlife.

The day when we could depend upon nature unaided as the chief provider of wild game for the sportsman's bag or the home table is largely past, except in limited areas, such as parks and wilderness. Wild game, fowl and fish were the first source of food and clothing in America, as for all civilizations before us. But as our modern agricultural economy developed in the wake of ax and plow, and our population multiplied, we found ourselves after a while with too little to hunt and fish, and with quail, cottontails and squirrels now chiefly a byproduct of cornfield, meadow and woodlot.

Because so great a percentage of our land has been fenced and plowed, the farms and ranches of today comprise the country's principal wildlife habitat. By the same token, the farmer is our principal game manager. Moreover, most of the water that supplies our lakes and streams, as well as a great deal of that which empties into the sea, drains from or across these same farm and ranch lands.

Yes, farmers and ranchers, as primary suppliers, will continue to have a great deal to say about our hunting and fishing. Their understanding of the importance of wildlife in our land economy is essential, nation-wide and in each community.

The Soil Conservation Service has been charged with the job of furnishing farmers and ranchers with the on-site technical assistance they need to improve and protect their soil resources. We supply that service to them, upon request, through locally organized soil conservation districts. We offer farmers technical assistance in three phases.

The first is a scientific inventory of soil and water resources adapted to the purpose of developing a sound and economical plan for conservation farming.

The second is assistance in determining the safe alternative uses and treatment for the land based on this scientific inventory, and assistance in selecting and combining into a practical plan those measures which will protect and improve the land resources, contribute most to a sound management program for the farm, and aid in the solution of watershed and other resource problems of the community.

The third is technical help in applying complex practices such as water control systems, drainage systems, terraces, and certain crop, pasture, range woodlot, and wildlife practices.

Furnishing this on-site technical assistance for soil, water, and plant management—aimed at soil protection and improvement, water conservation, flood prevention, and economic production on a sustained basis—is the primary job of the Soil Conservation Service.

A basic tenet of the Service program long has been that the conservation of land, water, forest, grass, cultivated crops, and wildlife must be tied together and scientifically coordinated on the basis of land capability and need. Encouragement of beneficial wildlife is an integral part of our soil conservation objectives.

Let us review some of the common soil and water conservation practices that are beneficial to wildlife by providing food and cover and general improvement of habitat. One of them is strip cropping, in which strips of tilled crops are alternated with strips of grass and legume crops. No less than seven and one-third million acres already have been converted to this pattern of farming in soil conservation districts.

Another practice is use of cover crops, with some 20 million acres planted with a wide variety of legumes and other plants. Stubble mulching is in use on upwards of 50 million acres in districts.

The wildlife benefits accruing from tree planting and farm woodland management are well known. The forestry part of soil conservation district programs to date has included close to a million acres of tree planting, between 11,000 and 12,000 miles of field windbreaks, and about 19 million acres of conservation woodland management. Meanwhile, range and pasture improvement, which improves food, cover and water for wildlife, has been applied on 78 million acres in districts; and range and pasture seeding has totaled twelve and one-quarter million acres.

Also, of course, there has been the substantial development of farmland areas specifically for wildlife, through developments such as field borders, planting odd areas, and protecting and improving marshland areas more valuable for wildlife than for agricultural use. As was the case with the other practices in the coordinated conservation program, more wildlife area improvement was accomplished in districts last year than in any year before, bringing to one and one-quarter million acres the total area thus treated.

Also important is the building of farm and ranch ponds, most of them primarily to provide water for liveestock, supplemental irrigation or other farm utility, but with attention given by our technicians to fish production and wildlife use. The Soil Conservation Service alone has given technical assistance in the building of more than a quarter of a million ponds in the last 15 years. Many of them have created duck habitats where none existed before.

That farm ponds are of value to wildlife is well illustrated by the use made of them by migratory waterfowl. A survey made by South Dakota in 1950 of that part of the state west of the Missouri River showed that in this area of 39,000 square miles there were about 40,000 man-made impoundments which contained about 100,000 acres of water, and which harbored 141,000 ducks. From this study it was concluded that through the construction of farm ponds a new breeding population is building up on the west river ranges—a population that in 1950 contained 23 per cent of the ducks in South Dakota.

In another study, blue-winged teals, mallards, pintails, and ruddy ducks were found nesting near and raising their young on ranch ponds in Colorado, New Mexico, and Texas. Eleven such ponds in Colorado supported a summer duck population of 107 birds, 73 of which were young. On five ponds, each with a water area of not more than one acre, a total of 50 young ducks were raised. Similarly, in many other parts of the West, ponds have made new habitat for waterfowl and have provided stopping off places during periods of migration.

On many farms in New York, Montana and elsewhere, water is being impounded on low, wet lands that previously were of little use either for wildlife or farm crops. A couple of hundred such impoundments in the Allegany Soil Conservation District in New York have proved their worth in attracting and sheltering waterfowl. One of them, a 6-acre marsh, produced three broods of mallards the first year and sheltered large flocks of migrating ducks and geese in the fall, in addition to attracting deer, raccoon and smaller wildlife.

A properly coordinated land-use program anywhere must of necessity take into account many factors besides just the development and management of plow land and pasture. Thus the Service considers the conservation and improvement of the Nation's woodlands to be an integral part of its coordinated program. Here, too, we approach the job, not as a primary forestry agency, but as a technical corps experienced in evaluating the capabilities of the land and in assessing the requirements of the farmer.

Part of our job is to encourage the landowner's appreciation of his woodlands in his over-all farm operation, and to help guide him in doing what is needed to protect, maintain, and utilize the woodland correctly. That is, not for wood products alone, but also for watershed protection, erosion control and wildlife habitat.

Our vast acreages of native grasslands, or range land, likewise are of such major importance in our agricultural economy that they require a proportionate share of our attention in developing the nation's coordinated soil and water conservation program. Here, of course, the primary objective is the improvement and maintenance of forage for livestock so essential to supplying us with meat, wool and leather. This same land, however, must support an important share of our wildlife. The job is to see to it that the needs of both domestic livestock and wildlife are met and soil moisture conservation problems solved.

Experience has shown that this can be done effectively through range improvement and management practices that result in more grass for better feed and ground cover, and development of adequate water supplies. Taking unsuitable lands out of cultivation and seeding them to grass or planting them to trees and discouraging the cultivation of grass and forest land not suitable for cropping also has helped immeasurably to improve the conditions for the perpetuation of wildlife.

Watershed development and upstream flood prevention work is a growing and important field of conservation of great interest to all who are concerned with improvement of our renewable natural resources. Watershed treatment includes, in addition to conservation farming, range management and forestry measures, many works of improvement, such as small flood-water retention dams and reservoirs, diversions, and channel stabilizing structures.

The benefits of watershed improvement to fish and wildlife are many. Flood-prevention treatment results in improved habitat for wildlife on watershed lands, through increase in grass and legumes, shrubs and trees. There are benefits to waterfowl, fish and furbearers through establishment of ponds, small dams, and other water-holding and water-retention structures, stabilization of stream flow, and reduced sedimentation of streams, reservoirs and estuaries.

Drainage of wet lands is a conservation practice about which there has been some difference of opinion between soil conservationists and wildlife conservationists. There are approximately 100 million acres of wet lands including marshes, swamps and small water areas in the United States at present. Much of this acreage is intermingled with drained land on thousands of farms scattered throughout the country. Estimates made from surveys by the Soil Conservation Service indicate that not more than one-fifth of the acreage of wet lands is suitable for cropland under present conditions. The other four-fifths of the acreage is not suitable for cropland or for pasture either because the soil is unproductive or it is uneconomic to drain the land. We know that much of this latter area can be improved for waterfowl and furbearers; and it is our policy to encourage such development by the owners.

Most of the drainage that has been done by farmers and ranchers with technical assistance from the Soil Conservation Service has been accomplished by tiling and open ditches on cropland and pastures. May I point out to you that less than 1 per cent of the seven and one-half million acres total drainage with which the Soil Conservation Service has assisted has affected swamps, marshes, or open water areas of any conceivable value to waterfowl.

Wildlife conervationists have been especially concerned about drainage in Gulf and Coastal Plains states. I believe that this problem can be resolved. The national needs for food and fiber at this time do not demand bringing much of this land into production. Under current price relationships, it is uneconomical to do so.

Whether extensive reclamation work in this area becomes necessary will, in my opinion, depend to a large extent on how fast we get on with the conservation job on land now in production. The faster we move on the job of improving and protecting the land now in cultivation in all parts of the country, the longer we can leave these lands for wildlife use. I consider some of this land as a reservoir of future potentials that can be put to crop use if our national food situation demands it.

There is, of course, some land in this area in farms now being operated where drainage is necessary to improved economic operations. Such an instance in Maryland was the subject of that state's winner in last year's soil conservation district speaking contest. His farm is in the swampy area of southern Maryland. Fields once farmed have turned to swamp because of silt deposits resulting from topsoil eroding from the higher land in the watershed. His richer deposits of wealth lie locked away in the swamps. He needs to get his land drained for economic production.

I am sure that wildlife conservationists understand his needs and want to see his drainage problem worked out. I believe it can be worked out without sacrificing wildlife.

Wildlife conservationists have also been concerned about pothole drainage in the Dakotas and Minnesota. Here, without doubt, there is a conflict of interest between the farmer and wildlife conservationists.

This problem has come about because of progress in modern agriculture. Years ago the potholes were difficult and costly to drain Working around them with horse-drawn machinery wasn't too bothersome. Now, machines have made it relatively easy to drain the potholes at relatively low cost. With the mechanization of agriculture, the potholes have become a bigger nuisance to the farmer. Farmers get stuck with tractors where they didn't with horses. Consequently, there has been recent increased interest in pothole drainage.

I believe there is a need for helping farmers to recognize fully the wildlife values of potholes. The farmers who own the land are the ones who need to be convinced. Decisions to drain are private decisions. We believe that if farmers have full information on the wildlife values of potholes, many would be willing to make the economic sacrifice and put up with the inconvenience necessary to leave them. Getting this full story to farmers, I believe, is a challenge to wildlife conservationists. It may be worthy of an education project on the part of your organizations.

Certainly, there is no conflict in thinking when it comes to such operations as tile and other field drainage for wet crop or pasture lands or rehabilitation of old ditch drainage systems. And when the landowner wishes to explore the possibilities of draining marshes, swamps or areas of open water, Soil Conservation Service technicians are guided by careful use-capability surveys that indicate soils which might be more useful for wildlife habitat than for agricultural purposes.

It is also Service policy, as a further safeguard to all interests concerned, to draw upon, in addition to its own engineering and other technical facilities, the advice of the Fish and Wildlife Service and the state wildlife agencies before detailed plans are prepared for drainage of swamps, marshes, and areas of open water.

It is only when wildlife conservationists and soil conservationists both work with farmers that it is possible to arrive at adequate information on the effect of any proposed drainage on both the land and wildlife and to bring to the attention of soil conservation districts and individual farmers the facts necessary to insure consideration of wildlife in the proper use and treatment of the land.

That is the Service's honest aim. In working toward it, we will go as far as we can to discourage drainage of land that is better suited to wildlife, particularly waterfowl, than it is to the production of crops. Sometimes, in fact, we have occasion to go even further, and help put water back on land instead of draining it off.

One such case in South Dakota offers an example. An old lake, from which the owner at the time took $600 to $800 worth of muskrats a year, finally went dry. Soil tests showed the lake bed was not suitable for growing crops or grass. Acting upon the owner's suggestion, our technicians designed a means of diverting water from a nearby small creek into the old lake area, of between 70 to 80 acres. Today, at a total cost of about $250 for the whole job, the land is under some 6 feet of water; the muskrats are back and on the increase; the lake now provides fine duck shooting; and the bulrush and cattail around the shore give winter shelter to pheasants.

While the Soil Conservation Service is trying to do all it can to protect and improve wildlife on the farms and ranches of the United States, technical assistance in conservation cannot fully dissolve the conflict of interest between farmers and wildlife conservationists. In fact, I doubt whether the conflict can be totally resolved without a more intensive effort to develop greater farmer appreciation of wildlife, and without methods for compensating farmers for hunting and fishing privileges.

On the basis of many reports from Soil Conservation Service technicians who have discussed the wildlife side of conservation farming with thousands and thousands of farmers and ranchers in all parts of the country, I would say that the personal pleasure and satisfaction of having fish and game on their own farms is perhaps its own best reward to most of them.

Many farmers tell us that one of the satisfying results of practicing soil and water conservation farming is the restoration of even better game than originally inhabited their farms. It is something they can enjoy and share with others.

A great many farmers, also, are enthusiastic sportsmen, who take to the field with their neighbors and friends from town and set a skillful pace with dogs, gun or rod. You don't have to "sell" them on the advantages of improving the game on their farms and in the community!

If the majority of farmers had such enthusiastic appreciation for wildlife values, it would contribute much to bigger fish and game crops—especially if there were some incentive for growing a bigger crop.

Direct returns from their increased wildlife have been realized and welcomed by many conservation farmers over the country. These range from fish and game for the table to revenue from furs, fish, and hunting and fishing leases.

Farmers in the vicinity of Lonoke, Arkansas, for example, are pioneering in a new type of conservation farming. It is water farming and follows a pattern long practiced in various parts of the Old World. A group of farmers cleared bottomland fields and leveed them to hold several feet of water. The "crop rotation" consists of fish and rice.

Food fish, mainly channel cats and buffalo, are bought by the farmers from commercial fishermen at low cost, fingerling size, and sold for about 25 cents a pound when they have reached 1- to 2-pound size. Production may run as high as 1,000 pounds an acre.

Growing fish benefits the succeeding rice crop. One of the Lonoke group is reported to have increased rice production from 60 to more than 100 bushels an acre after a two-year fish crop.

Among other sources of revenue from the Arkansas project has been the leasing of waterfowl hunting, for as much as $40 to $50 an acre.

A number of farmers near Saline, Louisiana, in the Dorcheat Soil Conservation District, have found minnow farming to be a safe and profitable use for land and water, on land formerly in cotton. One farmer built two one-tenth-acre ponds with Service assistance in brood stock, grew $200 worth of minnows. By 1950, he had 20 ponds totaling 3½ acres and grew 400,000 minnows selling for $4,000. A neighbor grew 300,000 minnows in 16 small ponds.

I'm sure you know of other examples of farmers turning a wildlife project into a good money-making proposition. Such enterprises, of course, are to be encouraged. Yet, the production of wildlife as an economic crop is highly specialized farming and relatively limited. While such enterprises will make a contribution to expanding our wildlife crop, demand can be met only by improving conditions for fish and wildlife on the majority of the farm land of the nation.

Those of you who attend this conference know the opportunities for improvement of conditions for fish and wildlife that have developed as a result of the formation of soil conservation districts in all states and territories. Almost every one of these districts has included consideration of wildlife among its objectives. Since the 2,500 districts already organized under state enabling laws cover more than four-fifths of the nation's agricultural land and include six-sevenths of the country's farmers and ranchers, their potential influence upon wildlife welfare is tremendous.

Soil conservation districts truly constitute an ideal focal point for bringing to bear the cooperative efforts from many sources that are necessary to meeting the problem of increasing production of beneficial wildlife on American farm lands. These districts have obtained cooperation in these efforts from the U. S. Fish and Wildlife Service, state game departments, agricultural experiment stations and other agricultural agencies and leaders, sportsmen's organizations and wildlife conservation groups, and other interests, including schools and youth organizations. Through the Pittman-Robertson wildlife habitat improvement programs, for example, 35 states now are providing assistance to soil conservation districts.

An apt illustration of the effectiveness of such teamwork comes from

South Dakota. It is the story of a section of land known as the "Fordham Section," which suffered severe soil blowing in the 1930's as a result of being farmed, and on which a 90-acre lake was formed behind a dam built with federal assistance in that period. The first year the Carpenter Soil Conservation District was in operation, 1941, the district and the State Department of School and Public Lands, which owned the land, worked out an agreement for improving this area for conservation, wildlife and recreational use. A development plan was initiated by the district with cooperation of the Soil Conservation Service, State Extension Service, State Department of Agriculture and State Department of Game, Fish, and Parks. Improvement since then has included more than 250 acres of seeded grass, sweet clover and other vegetation useful as cover for pheasants, and planting of 34 acres of trees in belts plus several thousand spot plantings. Bulrush was seeded on the lake shore for waterfowl cover. In 1946, a plan was worked out with the State Department of Game, Fish and Parks, under which the lake was stocked with several kinds of fish. The Department also took action to see that the spillway of the dam was repaired.

In the intervening years, private interests have sought to take over the Fordham Section for farming or other use, but the district and cooperating agencies have maintained it as a public shooting ground and recreational area. The district plans to plant more trees and grass and do more recreational development, including fencing against livestock to improve nesting grounds for ducks.

The support and cooperation which wildlife conservation groups have given soil conservation districts in the past have been most substantial, indeed, and have gone far in helping the districts to show the way to greater wildlife abundance through soil and water conservation work on the country's farm and ranch lands. The opportunities for continued and expanded teamwork in this field are virtually unlimited.

The whole, broad conservation job ahead depends for its successful advancement and completion upon the efforts and contributions of many people and interests working together. The goal is a coordinated, total resource-use program that benefits the entire nation, as a basis for building for future welfare and national security. It is to such a program—including increasing attention to wildlife needs and production as our conservation programs expand to more and more farms and watersheds—that the facilities of the Soil Conservation Service are dedicated.

It is gratifying that those interested in the conservation, use, and development of soil, water and the dependent living resources—cultivated crops, trees, grass, fish, and wildlife—are giving increasing recognition to the fact that the problems and aims of one are the concern of all. We have a big job to do—together—and I am confident that we are going to get it done, together.

DISCUSSION

CHAIRMAN SHIRLEY: Thank you, Dr. Salter. Do you have some questions for Dr. Salter or Mr. Dushinske?

MR. J. W. KIMBALL (U. S. Fish and Wildlife Service, Minnesota): I think, first of all, the Soil Conservation Service should be complimented on the fine job they have done in the stock-dam country of the western part of South Dakota, particularly. I do not think, though, that we should let that involve the issue of the effect on waterfowl. The stock-dam country produces approximately twelve ducks per square mile, while the prairie-pothole country produces about 140 ducks per square mile. We are very happy to see these new areas with these twelve ducks per square mile, but I am sure Dr. Salter did not intend to imply that this was replacing the areas which have been drained.

He said that one per cent of all drainage affects wildlife. That figure confuses many of us; but I am not questioning the figure at all. Undoubtedly he is right. The point I want to bring out is that this one per cent of drainage for agricultural purposes certainly cannot influence the over-all agricultural program to any great extent; it is only one per cent of the land drained. Yet it is destroying our national waterfowl population. Would it be possible for conservationists to select this one per cent, if that is it, of the land which is being drained and lost as waterfowl habitat so that soil conservation assistance and ACB payments would not be made on that one per cent?

DR. SALTER: It would be possible, but that would be a decision which would have to be made at a high level, as my predecessor on the program said. It is a decision which preferably should be made as the collective result of a meeting of minds of all the wildlife and agricultural interests, and be made at a level which would have the support of Congress, as well as the agencies themselves.

When we begin, either directly or indirectly, to impose the will of government or an agency on the right of the individual to make his own decisions with respect to the use of his private property, we are headed for trouble, unless we have clear legislative or governmental direction at the top. It is not something that an agency which is charged by Congress for the assistance of farmers through districts can legitimately take the responsibility for deciding. I do not want to see the time come when the Soil Conservation Service will have the responsibility of making the judgment between the agricultural values, which are the farmer's interest, and the social and esthetic values, which are the general public's interest. That certainly is not without clear-cut legislative or high-policy direction. The Service could get into terrific difficulties very fast, I am sure.

MR. WILLIAM VOIGT (Illinois): Mr. Chairman, I understand that this matter of ACB payment is not a Congressional matter, but is a matter which is determined by the Secretary; that is the extent or the purpose for which payments are made. I wonder if Dr. Salter can tell us whether, of his own knowledge, the Secretary of Agriculture is now considering any action to reduce, eliminate or to make more restrictive the making of ACB payments for pothole or slough drainage.

DR. SALTER: Mr. Voigt, we have no information at the present which would indicate that this is being considered. It may be, however.

MR. VOIGT: There has been no decision from the top levels, as far as you know?

May I ask one more? Would it be, in your opinion, a material benefit to the Soil Conservation Service, in determining whether to advocate or to discourage drainage in the pothole country, to have an adequate experience record and survey of the groundwater or water-table situation made by the Geological Survey or some other responsible agency?

DR. SALTER: I think the answer to that is yes. We need a great deal more of that type of information all over this country, to know just what is happening to our ground-water levels as a result of the control we are placing on water.

MR. CHESTER S. WILSON (Minnesota): Mr. Chairman, I would just like to follow up what has been said by the two speakers on this program, and the two preceding questioners. I happen to be President of the International Association of Game, Fish and Conservation Commissioners, which was mentioned earlier today; and I also happen to be a member of the State Soil Conservation Committee of Minnesota. Therefore, I am very much in the middle of this problem.

This pothole country which it at issue here centers around western Minnesota and eastern North Dakota and South Dakota. We are trying to do a constructive job of dealing with it.

I want to say that, as a result of our experience, I can heartily concur in practically everything which has been said by the two speakers on this subject. They approach this problem from different viewpoints, but not necessarily conflicting ones. But I think there are some serious misconceptions about the effect of the different factors which they discussed and what has to be done about it, which should be cleared up in this representative group from all over the country.

The first is that these ACB payments have been a major factor in inducing drainage, because, from all of our observations, they have not. I can illustrate that by calling attention to the fact that the total distribution of ACB payments in Minnesota is running at the rate of about six million dollars a year, an average of $60 a farmer a year. How much does that mean to a farmer in deciding whether he is going to drain?

Of course, some get more; some get less; some get none. But, in our judgment, the complete elimination of the subsidies for drainage would not have any major effect in dealing with this problem.

Neither can the Soil Conservation Service accomplish any major reform in this matter by what they can do, because a large part of the drainage is undertaken by farmers on their own initiative, without any help from the Soil Conservation Service.

I want to take my hat off to the Soil Conservation Service. I think the net result of their efforts has been a great gain for waterfowl and wildlife conservation, although they have been criticized for some of the things they have done. But let us not expect that they are going to do this job alone.

Now, we have made, in Minnesota, during the past year, a start on this constructive program which was mentioned by Mr. Dushinske, which was endorsed by our Soil Conservation District Supervisors' Association through an agreement with the Soil Conservation Service, which was not quite correctly stated by Mr. Dushinske. I think that it is important that it should be understood, because it can be applied elsewhere.

It is not quite true to say that the Soil Conservation Service has agreed to withhold service to a farmer on a drainage project until the Conservation Department can get in there and buy his pothole.

Our agreement with the Soil Conservation Service, which was started last year and is now set up on a permanent continuing basis, is that they will give us 21 days' notice of every drainage project which comes to their attention, so that our nearest Pittman-Robertson field man can go and talk to the farmer and, first, do what Dr. Salter emphasized, try to educate him on the value of wildlife on his farm. If that fails, then try to purchase from him either an easement or, perhaps, buy his wet land outright, and convert it into a state wildlife preserve. That, in substance, is our program.

Now, let's not kid ourselves; that cannot be done without money. This problem is urgent; it is critical, it is immediate, and that brings me to another problem which is very live right here in Washington today. That is what to do about this 13-million-dollar surplus in the Pittman-Robertson funds, because, in my judgment, if we are going to deal with this waterfowl problem, this pothole and marsh-drainage problem, in time we have to get some of that money out from the states so that they can have it to use in purchasing easements or the title to marshes and potholes which are critically needed to preserve this waterfowl production area. Once a marsh or a pothole is drained, you will never see the water again.

CHAIRMAN SHIRLEY: Thank you, sir.

MR. DUSHINSKE: My paper was to be primarily concerned with these subsidy payments, and I do not think we want to ignore that the subsidy payments have an effect on this. A gentleman told me, just before this meeting, that he had surveyed ten to fifteen farmers in Day County, South Dakota, and none of their potholes would have been drained unless they had had that help.

BIG DAM FOOLISHNESS

ELMER T. PETERSON

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Seventeen years ago I attended your Conference here in Washington as a delegate from Iowa. Jay N. Darling, our guiding spirit, was resigning as chief of the U. S. Biological Survey, disgusted over the maze of bureaucratic procedure and contradictory policies of overlapping agencies which prevented progress.

I shall never forget his remark about bureaucrats at the time. He said: "The trouble with these guys is that they don't read each other's memos."

Since then I have scrutinized the water-control policies of endless bureaus, congressional committees, boards and commissions. I am here today to declare, without fear of successful contradiction, that—so far as the prairie plowlands are concerned—the government has, within its own competent engineering and technical reports, information, which, if coordinated, would blow the whole big-dam program out of the water. Yet this big-dam program goes blandly ahead as if it were the only authentic flood-control method. So I repeat:

"The trouble with these guys is that they don't read each other's memos."

It is almost as if there were a conspiracy to keep actual facts from the people. How close to the truth this is may be appreciated by reading the recent report[1] of the House Subcommittee on Public Works, headed by Representative Jones, which recommends that the Secretary

[1]House Print No. 22, Report Subcommittee on Public Works, Dec. 5, 1952. Subject: Agricultural Flood Control.

of Agriculture shall no longer make surveys and investigations to determine the possibilities of watershed flood control.[2]

This is uncomfortably reminiscent of iron-curtain proceedings in which the Russian tribunal says, in effect: "If the truth hurts our side, pass a law against finding out the truth."

The Jones committee, conducting a swivel-chair investigation of the Washita valley from a distance of 1,200 miles, is so unfamiliar with the subject that it claims a table of comparisons in *Reader's Digest* about Little Washita Creek is "inaccurate," then presents what it calls "revised figures" which are even more favorable to agricultural flood control than the original table.[3]

The Jones report contains 43 pages, and it sweepingly condemns agricultural flood control—that is the program which stops water where it falls so that no floods are produced downstream. I emphatically endorse that program.

The Jones report is composed of pseudo-technical citations, plentifully sprinkled with inadvertent inconsistencies which actually argue on our side. For instance, it amazingly concedes that 25-year floods can be controlled by watershed structures of the SCS type.[4] Apparently the author of the report is blissfully ignorant of the fact that a typical multiple-purpose Army dam type in Oklahoma failed to control floods three times in eight years.[5] Yet it blithely assumes that the big-dam system is superior.

If you are confused by reading the Jones report, I will translate its over-all argument into a very simple parallel, using engineering arithmetic instead of half-truths or theories.

[2]"The subcommittee recommends: 1. That legislation be enacted to cancel present directives and authority for the Department of Agriculture to make flood-control surveys presently authorized under flood-control law or resolutions. . . . 2. That no additional authorizations for examination and survey for flood control by the Department of Agriculture paralleling authorization of the Corps of Engineers be made. 3. That so much of the Flood Control Act . . . as authorizes and directs the Secretary of Agriculture to cause preliminary examinations and surveys for runoff and water-flow retardation and soil-erosion be repealed."—Page 42.

[3]Middle of Page 18, Jones report, the table as presented in *Reader's Digest* is given. Alongside is a column headed "Current survey figures." Alleged discrepancies are:

	Original Table	Current survey figures
Flood storage, acre feet	59,100	59,108
Recreation pool, acre-feet	2,100	2,082
Flood pool, acre-feet	5,100	5,076
Bottom inundated, acres	1,600	1,464

[4]"The system of retarding structures proposed by the USDA was designed for a runoff volume of 4 inches over the watershed. This is estimated to occur no more often than once in 25 years."—Page 19.

[5]Pensacola reservoir (Grand River) overflowed in May, 1943; May, 1950, and July, 1951, each time contributing to bad floods below the dam. In 1943 it contributed half of the catastrophic flood on the Arkansas River which drowned 19 persons and caused $127,000,000 damage.—Newspaper accounts of respective period . . . *Saturday Evening Post,* Aug. 21, 1943. Moreover, Fort Gibson Dam, finished below Pensacola two months before the 1950 flood, permitted 120,000 cubic feet a second to flow over it, contributing to bad flood below. Dam builders had had eight years' warning to relocate tracks, highways, and other facilities. It should be noted that far greater downpours on SCS-treated subwatersheds in Oklahoma, in 1950 and 1951 cloudbursts, were being controlled by the SCS methods. The SCS program had not yet been started at the time of the 1943 flood.

Summing up the thesis of the report, here would be a parallel:

"We contend that one 30-gallon barrel will receive and store more water than 100 one-gallon buckets, even when that barrel is frequently caught full or partially full, whereas the buckets are always kept empty."

To show how generous to the big-dam cult I am in making this comparison, I call attention to the official engineering figures which show that a typical small detention dam in the Mill Creek watershed of Oklahoma is positively engineered to impound 5.22 inches of runoff, and this constant impoundment capacity is guaranteed by the automatic draw-down outlet pipes; whereas the huge Denison Dam of the Army Engineers would not possibly impound in its flood pool more than 1.31 inches of runoff from its own respective watershed, which includes that of Mill Creek.[6] You see this ratio is four to one in favor of the little dam. Even with an empty flood pool, which cannot be guaranteed in a multiple-purpose reservoir, the big reservoir is inferior.

This big reservoir, like practically all the prairie reservoirs, is a multiple-purpose structure, so the flood pool is seldom empty except in time of unusual drought. Official tabulations in our state show that, as a rule, the bigger the dam, the less it is able to impound runoff.[7] Yet the Army Engineers at Omaha, in what purports to be an expert discussion of flood control, state precisely the opposite. They do not cite supporting engineering facts. An extraordinary phase of the current controversy between downstream flood control advocates and watershed associations is that it is we watershed flood control proponents who are giving actual engineering facts and figures, while the big-dammers are the ones who deal in theories, claims and unsupported opinions.[8]

In this connection it is necessary to refer to the remarkable situation in which certain high officials of the U. S. Department of Agriculture are quoted as saying: "We *don't claim* that the SCS program will stop floods on the main streams." The realistic fact is that it makes

[6]Statistical information on file in SCS state office, Oklahoma City, and regional office, Fort Worth, Texas.

[7]The little detention dams of SCS are engineered to impound up to 5.22 inches of runoff. In regions of sparser rainfall the capacity ranges down to 3 inches. The medium-size Army Engineer dam projected for the Little Washita subwatershed was designed to impound 52,000 acre feet, compared with 59,108 feet for the 34 SCS dams.—Revised table used in Jones report, Page 18. Also engineers' report in SCS offices.

[8]Abundant citations available, for instance in Peterson articles and speeches, compared with quotations like the following from Gen. Lewis A. Pick, testifying in hearing of Committee on Public Works, on "Floods in Kansas and Missouri, 1951" (Page 8), Gen. Pick. "There has been a widespread theory that you can control floods by building small reservoirs over a wide area. . . . I do not subscribe to that for this reason: In my *opinion*, . . . you would have had to provide much greater storage . . . and you would take up much more land in the reservoir areas." Page 11: "It would cost terrifically to build enough small ponds. . . . It would take more land, cost more money, etc." (Directly contrary to actual facts.)

no difference what they claim or don't claim—the statistics conclusively prove that the SCS program *will* stop floods on the main streams because it is already doing so on the tributaries of main streams, and the main streams have no source of water except those tributaries.[9]

Perhaps it is not for me to judge *why* these few USDA officials belittle their own program, but the inescapable conclusion, based on events, is that they are intimidated by the Army Engineers; so, without producing any figures to support their feeble *nolo contendere,* they make this blanket statement to keep peace in the great family of bureaucracy. Back of this farce, of course, is the fact that various politicians, in an effort to carry water on both shoulders, have laid down impossible constricting procedures, like those of the inter-agency committees. One such politician is so anxious to please both sides that he announced that he is going to ask for a legislative investigation of the relative merits of watershed *versus* downstream flood control, adding that he is sure the big dams are necessary in any case. This is reminiscent of the Panhandle judge who said: "I'm going to give the defendant a fair trial, and then find him guilty."

My own thesis, backed up by voluminous evidence, is that agricultural watershed flood control, in the average prairie plowland area, is vastly superior to that which is purportedly furnished by huge reservoirs. Here are ten chief points of superiority, each supported by high authority.

1. In the single item of runoff impoundment, the little detention reservoir has far greater capacity than the big one, proportionate to watershed area. *It is planned that way.* Five subwatersheds, thus far, have been given the SCS treatment in the Washita valley, aggregating not far from 100,000 acres. Each one, since 1948, has received a severe performance test. Impoundment capacity ranges from three to more than five inches of runoff. Soil conditions and topography vary greatly, including hard and sandy lands, sod, timber, croplands, rolling land and very gentle slopes.[10]

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[9]Any elementary book on mathematics says that "the whole is no greater or less than the sum of all its parts."

[10](a) Cloud Creek subwatershed in 1948 absorbed 4.6 inches of rainfall in 4 hours without even filling the permanent pools of detention dams up to drawdown tubes, whereas neighboring creeks were badly flooded. (b) Treated part of West Owl Creek in May, 1950, absorbed up to 15.5 inches of cloudburst in 36 hours and creek below structures kept within banks until it had gone a mile past the last structure; by that time it was receiving runoff from untreated slopes below. This is verified by isohyetal maps and statistics on file at Oklahoma City office of SCS and Regional SCS office at Fort Worth, Texas. (c) Mill Creek, in southern Oklahoma, had flooded regularly and badly up to 1950. Its treated portion in May, 1950, absorbed a downpour reported by residents at 6 inches within 24 hours, without flooding. (d) Sandstone Creek, with 65,000-acre watershed, in May, 1951, received about 5 inches of rain, judged by the nearest official gauges, and none of the detention reservoirs discharged through their drawdown tubes. (e) Upper Barnitz Creek, near Clinton, Okla., in May, 1951, received a cloudburst of 13 inches within 24 hours, and it did not go out of its banks because of the impoundment, insoak and gradual drawdown, though neighboring creeks were on a wild rampage, doing great damage. These five provide 100 per cent performance, doing even better than was expected by the engineers who planned the structures and treatments. I have

2. The second great line of defense against floods *on the main stream* is *insoak*, which has proved itself amazingly.

On the West Owl Creek subwatershed, SCS engineers figured four or five inches reservoir impoundment and about three inches of absorption by insoak. In an unprecedented cloudburst in 1950, the treated part of the watershed was expected to absorb a 25-year flood, or about 7 to 8 inches. The engineers were flabbergasted to find that it took care of a 100-year flood, in which 15.5 inches of cloudburst fell within 36 hours.[11] The overage resulted from unexpected heavy insoak.

Almond D. Bull, SCS specialist on infiltration, has conducted field research showing that when good soil conditions are brought about, an insoak of as much as 4.5 inches *per hour* takes place, and that there is no chart curve indicating saturation, but a constant absorption, with continuous, steady infiltration to lower levels.[12]

A prime factor in this insoak is the breaking of what is called the plow-pan, which is not necessarily caused by the moldboard plow, as once presumed, but by a natural coagulation of fine clay particles four or five inches below the surface. Techniques include the use of sweet clover and other pan-penetrating crops, the use of the chisel plow, deep moldboard plowing, terracing, regrassing, contour furrowing, and related practices.

Forestation has been used by Johns Hopkins University at Seabrook Farms, New Jersey, as an insoak medium, and water sprayed in the woods, even up to *50* inches in *ten hours,* and up to 100 feet of water a year in certain spots. The classic example of Nature's own forest insoak is seen at Cherrapunji, India, where jungles constantly absorb the average of 426 inches a year in rainfall.[13]

3. The drawdown tube of the small detention dam furnishes the third substantial line of defense against *floods on main streams.* This is analogous to the automatic flood-gates of the Miami Conservancy District in Ohio, also known as the "dry-dam" principle, and *not*

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closely inspected all of these projects, and find that they include every major type of farm, pasture and timber land customarily found throughout the Midwest farm belt. My farm background is agricultural, in Iowa, Kansas and Oklahoma. These tests are fair for all farm states.

[11]Official U. S. Weather Bureau maps, isohyetal maps and reliable rain gauge reports form the basis of this record. The five subwatersheds mentioned in this documentation, under No. 9 had not received intensive insoak treatment, such as chisel plowing or special vegetative techniques employed by Mr. Bull, but ordinary cultivation, with terracing regressing and related practices. The copious insoak is therefore all the more surprising.

[12]Articles in Farmer Stockman (Oklahoma), Daily Oklahoman, etc., quoting Almond D. Bull. 1951 and 1952.

[13]National Geographic Society press release, Nov., 1952.

found in the huge multiple purpose structures.[14] It automatically empties the flood pool and makes it ready for the next downpour.

4. Inundation of millions of acres of our best bottomlands has to be charged against the big reservoirs, but not against the small detention dams, which use waste or inferior land for storage space. With our heavy increase in population, we are getting perilously near the two-acre-per-capita allotment of good farmland, especially since we are losing 500,000 acres[15] per year by slope erosion. We just can't afford to submerge 50,000 to 100,000 acres at a clip for big reservoirs. The wanton sacrifice of 50,000 acres for Tuttle Creek Dam in Kansas, destroying an annual farm production of $6,000,000, besides other considerations even more valuable, is a red light of warning.[16]

5. Sedimentation is another terrific drawback of big reservoirs. Publication No. 521 on sedimentation of reservoirs, by the U. S. Department of Agriculture, is a typical report which shows that "these guys don't read each other's memos," as mentioned a few minutes ago.[17] This report alone, with its tabulation of prairie plowland reservoirs rapidly filling with silt, should be suffcient to blow the whole big-dam program out of the water. Being phrased in the usual cautious technical terms, its import is not readily grasped by the layman. But the unquestioned facts bring such inescapable conclusions to anyone who analyzes them.

The peril is not only that of the filling of the reservoir itself, which in the average prairie plowland case will happen in about 50 years. The far greater peril is backwater sedimentation, which my good friend Arthur Carhart calls "aggradation."

I have in my hand a blueprint of the Army Engineers[18] which forecasts ultimate backwater sedimentation on the Washita River to a distance of 100 river miles upstream from the Denison (Texoma) reservoir. However, Dr. Harold H. Munger, professor of hydraulic engineering at Kansas State College, who has made an intensive study of siltation, says that this estimate is far too modest, as the new bed of the river tends to be built up parallel to the old bed at a height equal

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[14]Plaques mounted on the Miami Conservancy District flood-control dams carry this inscription: "The dams of the Miami Conservancy District are for flood prevention purposes; their use for power development or for storage would be a menace to the cities below." It is axiomatic that it takes a full reservoir for an ideal power or storage container and an empty reservoir for an ideal flood control instrument.

[15]*Three Acres*, pamphlet of Oklahoma A. & M. College Extension Service. Circular No. 476. "Your Three Acres . . . are all that stand between you and starvation."

[16]Publication of statistics issued by Blue Valley (Kansas) Protective Association. President: Glenn D. Stockwell, Sr., Leonardville, Kans.

[17]Miscellaneous Publication No. 521, U. S. Department of Agriculture. Note especially second paragraph of foreword, Page II; statement at bottom of Page 7; top of Page 8, table on Page 20; first paragraph Page 27; photograph on cover.

[18]"Backwater Curves Denison Reservoir Washita River" blueprint made by Corps of Army Engineers

[19]Series of letters from Dr. Harold H. Munger.

to the height of the dam, and that in typical prairie streams deposition can be expected even up to a one per cent gradient.[19] This formula rests upon recognized geological indices.[20]

The U. S. Geological Survey confirms the phenomenon of backwater sedimentation in an interesting letter which I have.[21]

The terrific destruction wrought by backwater sedimentation in the Rio Grande flood plain above Elephant Butte reservoir is vividly described by Arthur Carhart in his book, *Water or Your Life.*[22] I have personally gathered facts and figures showing that backwater sedimentation caused by big reservoirs is causing upstream floods in Oklahoma.[23] These are fortified by abundant photographic evidence which I also have. When President Truman and General Pick flew over Miami, Oklahoma, in July, 1951, they saw a flood which drowned one man and did $5,000,000 worth of damage. What they didn't know was that this was caused by the presence of the huge Pensacola Dam, downstream.[24] At the same time they were prescribing more such dams, ostensibly to *control* floods.

6. Wildlife ecology is being rapidly destroyed by big prairie dams. As pointed out many years ago by Jay N. Darling,[25] these create "biologic deserts" because the silt chokes aquatic vegetation upon which aquatic animal life ultimately depends. Spawning beds are

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[20]Typical prairie streams arrive at a state of equilibrium in which the conflicting forces of scour and fill finally equalize and form a stable channel, barring abnormal disturbance. The coming of the plow caused such disturbance, so rivers rebuilt themselves by geologic laws to form new gradients and channel width, etc. Any obstacle that causes slow-down of current starts a new process in which the same gradient tends to be repeated, at a height equal to the height of obstacle.

[21]U. S. Department of the Interior—Geological Survey—Dec. 8, 1952. "You are correct in stating that the heavier sediment carried by a stream will be deposited in the backwater area of a reservoir. This is due to a decrease in the velocity of the stream as it enters the quiet waters of a reservoir." Also letter from Edgar L. McVicker, Chickasha, Okla., August 6, 1951: "I went to the Bureau of Reclamation in Altus to get some information about the sedimentation rate of the lake. . . . One of the engineers . . . pointed out that for several years that lake filled with sediment as expected, but after this period the rate of fill decreased. I asked why. . . . The answer he gave was as follows: The sediment back-filled in the stream channel above the lake. Each year it moved upstream."

[22]Pages 200-204.

[23]Letter from W. R. Holway, consulting engineer for Pensacola Reservoir (Grand River Dam Authority, Oklahoma), admits that sedimentation of old Neosho River channel at head of lake amounts to as much as 18 feet in three places. Letter from Dr. Harold H. Munger, hydraulic engineer professor at Kansas State College, says the shallower the flow, the slower the current, and the slower the current the more rapid the siltation, so overbanks (old flood plains) accumulate silt even faster than old channels. Photographs support findings. The 1951 flooding of Miami was caused by inability of water to get away, down-lake, fast enough. According to the Army Engineers' reports in the Daily *Oklahoman* in the period of July 10-12, 1951, there was a difference of 23 feet between the water level at the dam and that at Miami, just above the head of the lake, which proves the difficulty of flow, caused by the "hidden dam" or bottleneck caused by siltation. Parallel findings were made above Lake Texoma (Denison reservoir) on Red River, and up Beaver Creek, where Waurika, Okla., was flooded six times in the summer of 1951—a phenomenon that had never happened before the building of Denison Dam. Photographs support other findings.

[24]See above.

[25]Darling strenuously opposed all big dams in low gradient farm areas. He called special attention to the reservoir formed by Keokuk dam, where siltation destroyed fishing and even made it impossible for clams to live, so that a pearl-button factory had to quit business.

destroyed by siltation.[26] River-bank ecology is violently disrupted and stream-fishing disappears.

I plead especially for the kid with the bent pin and can of worms, who used to be common along our steadily flowing clear streams, but who has disappeared from our prairie countryside. Rapid runoff through 200 million new gullies[27] and channel siltation have done their dirty work. We should stop water where it falls, keep soil where it is, raise the water table, revive old springs, start creeks running clear all year, and insure a steady flow of clear water in rivers.[28] Incidentally the small SCS detention dams, protected against siltation by soil conservation practices, are proving to be fine fishing water.

It has become a familiar truism that soil conservation and propagation of wildlife habitat and cover go hand in hand. No force for advancement of sound wildlife management is so powerful or effective as that of Mother Nature, who is one woman who always has the last word. She has shown by infinite experience proof that good soil conservation practices parallel, equal and surpass the operations of the wilderness, so far as the general biology is concerned. Darling, like his many able colleagues everywhere, has abundantly shown that sound practices, including prevention of overgrazing, have restored vegetation, raised the water table and restored wildlife habitat. The big-dam movement not only fails to produce such effects, but positively antagonizes such a program.[29]

7. Soil conservation, in itself, besides its enormous value to wildlife management, is of utmost importance to all. It is shown by a four-state survey that it immediately adds 32 per cent to average crop production, thereby enormously increasing the over-all economic potential. The big dam program *erodes* millions of acres of our best and most fertile land out of the total area, by direct inundation, which is even more deadly than the wash of soil on the slope. To cap the climax of destruction, it produces progressive blight of backwater sedimentation, to ruin bottomlands upstream from inundated areas. How a

[26]The federal hatchery supervisor at the mouth of the Washita River gave a newspaper interview as of about 1950, saying that fishing is ultimately doomed in Lake Texoma because of destruction of ecological conditions for fish, especially game fish.

[27]Dr. H. H. Bennett, quoted in article "Floods Are Unnecessary," *Saturday Evening Post*, Aug. 21, 1943, stated that the plow brought 200,000,000 new water courses by gullying and that each year 117,000,000 tons of nitrogen, phosphorus, potash, magnesium, calcium and sulphur are washed away, compared with 19,000,000 taken off by crops and grazing.

[28]In the same article Dr. Bennett cites the case of the Palouse River, in Washington, where conservation practices on three-fourths of the watershed acreage restored primitive ecology favorable to trout, as indicated, through revival of dead springs, restoration of clear creek flow, etc. Countless parallel instances have been made known. Louis Bromfield, on Malabar Farm, during the drought year of 1946, had plenty of water in springs and wells while his neighbors were forced to haul water. Bromfield used a deep-stirring chisel plow, causing insoak.

[29]Typical attitude of Army Engineers is seen in statement made by Gen. Lewis A. Pick in hearing of Public Works Committee, July 31, 1951. He ridiculed the SCS agricultural flood control program, bottom of Page 8, near bottom of Page 10, middle of Page 11, and context. He betrayed his lack of knowledge as to insoak at bottom of Page 14.

USDA man can encourage big downstream dams in view of these proven facts is an incredible proposition. He betrays his own cause.

8. The atomic age has brought a unique double-edged situation. It has insured that hydro power, once a fetish of big-dam promoters, will soon be obsolete. It is already more expensive than steam-generated power in the low gradient areas.[30] This atomic age has also created a new and hideous threat to all communities in flood plains below large dams, including radio-active contamination. The bombing of the Mohne and Sorpe dams of Germany by the RAF in World War II produced appalling disaster.[31] This is not a theoretical menace but a most realistic one, and no one knows this better than the Army Engineers themselves, for it can be assumed that they had a part in the bombing of big river dams in Korea.

9. It is estimated[32] that 16,000,000 tons of rich stinking mud was deposited in the Kansas City bottoms in the 1951 flood. This represents a far greater economic loss than the damage to urban installations by the surge of water, because it was a small fraction of a tremendous wash of rich land-soup from the tributary territory.[33]

10. The big multiple-purpose dam is a broad entering wedge for nationalization of power. Power is the key to all industry. Here we find abundant documentation.[34]

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[30]Statement by Don McBride, then director of the Oklahoma Planning and Resources Board, in 1942, shows by analytical figures that steam power, generated by coal and natural gas, is cheaper than hydro power. The differential is even greater now. Gano Dunn, as president of the White Engineering Co.—recognized authority on hydro power—substantiated this about the same time. In recent years the public power lobby has succeeded in securing appropriations approximating three-quarters of a billion dollars to build steam plants in the heart of the TVA hydro area, because hydro power is more expensive and less dependable than steam. The public power enthusiasts who have moved into REA are building steam plants in various parts of the country, at the same time lobbying for big dams on the pretext that they are valuable for power producion.

[31]Recital of bombing in Encyclopedia of World War II.

[32]Television presentation by National Association of Manufacturers.

[33]Numerous articles by Dr. Jonathan Forman (President, Friends of the Land) in *Land News* and other publications, emphasize the fact that the topsoil contains a vast variety of essential substances like hormones, enzymes, vitamins, antibiotics, etc., revealed by modern science, along with major elements of fertility and trace elements upon which formation of enzymes and other substances depend, and the loss of such substances has a serious and direct effect upon health and well-being of animal life and human beings. Supported by other authorities, like Albrecht, Picton, Cocannouer, Fink, Sir Albert Howard, and Lady Eve Balfour. The valuable elements and substances, often found in light organic matter, are quickly churned out of muddy flood-water and sent over the dam, leaving only dead rock-dust in the silt beds. Soluble material escapes, leaving only the "biologic desert" mentioned by Darling and others.

[34]Brochure *Encroaching Socialism*, made up of photostatic copies of documents, compiled by *Public Service Magazine*, Pioneer Bldg., St. Paul, shows that the TVA (as pilot project) and entire big-dam program was initiated as a Socialist party program, beginning about 1917, and the main architect was H. Stephen Raushenbush, who outlined the plan in *The New Leader*, leading Socialist paper, March 5 and 12, 1927. He said: "Our long time aim is the abolition of the profit system for private use. Our strategy is to make and take every opportunity to prove that it works. We must force our experts on agriculture, trusts, coal, power, subways, housing, milk, etc., to tell us correctly which the next steps are, and then take them and identify ourselves with their success." The headlines for the two installments of his article were: "CATACLYSMIC SOCIALISM OF ENCROACHING CONTROL" and "A PROGRAM FOR THE GRADUAL SOCIALIZATION OF INDUSTRY." Raushenbush entered the Department of the Interior in 1939; by 1941 he had become Chief of the Planning Section; he resigned as Chief of the Economics and Statistics branch of the Division of Power of the Department of the Interior, Jan. 15, 1947. The first TVA bill was passed in 1924, the result of the Washington Conference on Super Public Power, launched by the Socialist party.

In conclusion, I regret that time has not permitted a more thorough discussion of the various points, but again I invite you to refer to the documentation if you are interested.

I have proved that agricultural flood control is the modern scientific method which should replace the obsolete surface reservoirs of the Army Engineer type and magnitude. I charge that the Army Engineers do not understand large-scale flood control, and this charge is abundantly supported by the report of July 2, 1952, of the Subcommittee on Army Civil Functions, Representative John H. Kerr, chairman. This report shows, among other things, that the $250,000,000 program, ostensibly to control floods on the Missouri River, ***has actually made floods worse.***[35] The Chief of Engineers was present at the hearing and offered no rebuttal. With such a situation in the background, and with ample high engineering authority[36] on my side, I submit this case.[37]

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[35]"Missouri River Channel Stabilization and Navigation Project"—Report to the Committee on Appropriations, House of Representatives, by Mr. (John H.) Kerr, from the Subcommittee on Army Civil Functions, 82nd Congress, Second Session. See, especially, first paragraph of Introduction, Page 1; 5th line Page 2; 5th to 7th line from bottom Page 2: Abridged report. See also middle of Page 13, full report; Lines 7-10, Page 19, full report; Lines 7-18, Page 42, of full report; and full context.

[36]Courtlandt Eaton, Golden, Colorado, veteran outstanding hydraulic engineer and designer of big dams and other important hydraulic works (see biography in *Who's Who in Engineering*) in letter to Peterson, dated July 1, 1952, says: "The principles you express ('Big Dam Foolishness,' *Reader's Digest,* July, 1952) are sound from an engineering, economic and common sense standpoint. . . . Among the advantages (of numerous small reservoirs) are: (1) Speed of construction . . . (2) Safety to lives and property . . . (3) Flexibility of operations. . . . My own opinion is that an acre foot of suitably apportioned multiple storages will have an effective control value of 4 acre feet in a single large reservoir located downstream. . . . (4) Erosion control . . . (5) Groundwater recharge." The above points are elaborated and explained in engineering terms. Analogous endorsement of this article has been received from other authoritative engineering sources. The state of public opinion, typical of the prairie plowland area, was evidenced in the election Nov. 4, 1952, when the First Kansas District, which had never gone Democrat before (the incumbent Republican, Albert M. Cole, was re-elected Representative by 30,000 majority in 1950) made the Tuttle Creek Dam the sole issue and elected a comparatively unknown Democrat, Howard S. Miller, by 3,800 majority. (See editorial *Saturday Evening Post,* Jan. 3, 1953.) The ten states of the Missouri Basin, in emphasic resolutions, March 20-21, 1950, at Mitchell, S. D., condemned the Pick-Sloan program and similar programs and demanded watershed flood control. Numerous watershed associations, in Kansas, Nebraska, Missouri, Iowa and elsewhere, militantly make the same demands. The Ten-States resolutions, adopted by the "Associated Missouri Basin Conservationists," were guided by the eminent conservation writer, William Vogt. His near-namesake William Voigt, director of the Izaak Walton League of America, has taken similar militant leadership in his circles. The Missouri Wildlife Federation takes the same kind of stand, under leadership of Edward Beecher, Bud Jackson, Gus Beillmann, Msge. Hildner and others. In Kansas Dwight Payton, president of the Kansas Watersheds Association, aggressively makes the same kind of fight. These are but fragmentary evidences of the revolt that is sweeping over the Mississippi Valley, and letters from all over the United States indicate a similar popular opinion.

[37]To supplement item No. 23 in documentation, it should be explained that the Army Engineers, interviewed by the *Oklahoman* and Oklahoma City *Times* in the period from July 12 to July 15, 1951, said that Pensacola Dam was overflowing at the rate of 80,000 cubic feet per second, and the level of water at the dam was 755 feet above sea leevl. At the same time the water in Miami stood at 778.52 feet above sea level. This, they said, was 10 feet higher than the disastrous flood of 1943 which drowned 19 persons and did $127,000,000 worth of damage on the Arkansas River, into which Grand River (under Pensacola Dam) empties. In 1943 this dam had been but recently completed. There was therefore a slope of 23.52 feet on the water's surface between Miami, just above the head of Grand Lake, and the dam at the lower end of the lake. I visited the entire area involved immediately after the flood, and found that the steepest part of this slope had occurred some distance below the head of the lake, showing that there was serious retardation of flow just below Miami, at the head of the lake. I found heavy deposition of mud and silt on the floodplain between Miami and the main body of the lake, and took photographs, one of which showed at least 2 inches of

DISCUSSION

CHAIRMAN SHIRLEY: Thank you, Mr. Peterson. That is another very stimulating talk.

Inasmuch as our last speaker's talk also deals with this question of controlling waters in major streams, we will again defer discussion until after we have heard his paper, then discuss the two together.

I am pleased to present now Mr. Nathan Tufts, president of the Connecticut Valley Watershed Council, who will talk on "Grass Roots Control in Watershed Plans and Management." Mr. Tufts.

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mud deposit on an old blacktop road, showing that the deposit had occurred in the one flood. It is therefore evident that the flood menace to Miami will progressively increase with the constant deposition of silt.

The writer is especially indebted to R. C. Longmire, president, and Dave Vandiver, vice-president, of the Washita Valley Council of Oklahoma, for important information and encouragement.

GRASS ROOTS CONTROL IN WATERSHED PLANS AND MANAGEMENT

NATHAN TUFTS

President, Connecticut Valley Watershed Council, Greenfield, Massachusetts

Man has always chosen the valleys for his work and play. Our North American Indians lived where streams and rivers provided water, where wild game and fish lived also, and where the fertility of the soil made his agricultural pursuits less arduous. For hundreds of years, and still, the valley streams were the best means of transportation. Small settlements grew into cities—people must live near their work. Industry needed a flow of water for power and other purposes. I suspect a thousand years from now even visitors from Mars, in their flying saucers, will prefer valley landings, where a bright moon on a clear night gleams back from the watershed.

In a day of federal and bureaucratic jurisdiction and exploitation, men pugnaciously cherish and seek, through self-determination, the rich natural resources of any great watershed.

This is as it should be. Were it not for the allurement, our states would sell fewer hunting and fishing licenses; our neighbors from friendly regions would not seek the enjoyment and refreshment of a great valley for vacation, and busy men would be loath to work and live where they could not relax with gun and rod and, yes, with axe, in field and stream and woodlot.

New Englanders look upon the Connecticut River Watershed as one of their very finest heritages. Its 400 miles in a north-south directional flow, its 27 important tributaries, its 11,000 square miles of farm and forest and marginal land, its industry and power and growing economy provide a constant challenge to the 1,500,000 people who live within this great watershed. Whether they be residents of Connecticut, Massachusetts, Vermont or New Hampshire, they strive to protect and improve and further explore both the natural and man-made resources which exist.

You gentlemen are interested in trends—the direction, the prevailing tendency or drift—of land and water use. In the Connecticut Valley the river itself is the only thing that hasn't changed. It still runs downhill, but the people are of a different mind. They are looking up. Water over the dam is forgotten in New England. They don't even pause to look at what's going by. It's what's above, ahead of us, the future that counts.

Ours is a "grass roots" effort with a very fixed objective. We want control at the local level and economic development and progress with a big SELF in front of it.

Watch our valley town meetings, in Brattleboro, Vermont, for example. Pollution of one of the town's small streams, Whetstone Brook, was in the warrant—in the form of a $280,000.00 self-conceived, self-planned and self-executed sewer-to-be. They turned the job over to the selectmen.

The people who did this are farmers, woodlot owners, sportsmen, merchants, industrialists. Some are non-residents who pay taxes too. Professional people, members of fraternal groups, members of civic organizations, granges, chambers of commerce, institutions, recreational groups, parent teachers' associations — people who work and play and join—not easy to satisfy by any means. They are men and women who like the three C's—Conceive, Control and Complete, and what they work and fight for is worth a lot more to them and you than what comes out of the pork barrel. Not many years ago, when a lot of that good Vermont grassland was threatened by a government-sponsored flood control project, Vermonters did a lot of thinking about their pitchforks, got 'em out and shined 'em up and someone blew retreat on the bugle.

Development in the Connecticut Valley, from the point of view of power and flood control, has been wise and judicious to date. The four states bordering the Connecticut are cooperating in new self-development programs, pollution compacts, natural resources and inter-agency work. There is a philosophy of cooperation since the people went to the polls last fall. The more we have of the same sort of thing across the breadth of our country, the better off we'll be. We hope our leadership is contagious.

So we're going to better the use of our natural resources and do that job. Money will come from Mr. Public Spirited Citizen through democratic organizational procedures. Those who join hands and contribute will decide *what* will be done and how we will educate others. Cooperation with allied services is fundamental. There is no compulsion. It is persuasion towards the wise handling of basic resources emphasized in the fields of water and land, pollution, soil conservation, better forest practices, improved wildlife management. This is an operation bootstraps. The program is underway on the Connecticut's tributaries. It's self-help instead of government subsidy. We're going to do it ourselves.

More than a year ago, leaders in the life of the Connecticut River basin met in historic Hanover, New Hampshire, the site of Dartmouth College, which institution incidentally, under an old land grant, capably manages, from a point of view of complete conservation, its 27,000-acre land holdings, and there they listened for two days and a night to the challenge thrown out by experienced men and valley leaders. They heard what had been done in more than 30 other river valleys. They were impressed by the potentials which lay around them. Some, by comparison, little realized how negligent the residents of the Connecticut had been in promulgating action toward adequate pollution remedies, proper forest cutting practices, better wildlife management and improvement, a scientific disposition of marginal land and the rather slow development for the economic good of the valley of its other natural resources. They were aware that the Federal Government had spent huge sums following the disastrous floods of 1927, 1936, and 1938. They were conscious that the almost fully developed water power resources of the river had greatly benefited their industry and private lives, and they were in full realization that a certain transition had taken place in the last 50 years from early days of forest and field exploitation, to a more rigorous and more costly era of grubbing hard to create greater utilization in a time when competition forced them to do so. They left Hanover determined gentlemen. In the late spring, in Greenfield, Massachusetts, 50 incorporators established the Connecticut River Watershed Council. Its policies and purposes, as incorporated in its charter, were to promote the restoration and conservation of the natural resources of the Connecticut River watershed; to assist in protecting and conserving fish and wildlife, forest and other plant life, water sources and soils; to promote and encourage an understanding among the citizens of the valley of the need for such conservation; to conduct scientific investigations and research to aid the accomplishment of the above purposes; and to help promote through coordination and integration those activities of other agencies and organizations having an interest in the natural resources of the watershed, which proved to be truly in the public's interest.

Today we have grown in membership, have able consultants and executive directors, have a four-state group of officers, vice-presidents and directors, who comprise the men whose private and business interests give the enthusiasm required. As we grow and expand and find funds to accomplish our purposes, we will consequently be able to discover both small and large ways of using the heritage of which I have been talking, so that it can be made more useful and a greater contributor to our over-all economy.

Now this is not a new undertaking. Both individuals and large groups can point with pride to similar projects which have been ultimately successful. It is, however, because of the extent of the area involved, a project of considerable proportions, that before a distinguished group of conservationists, such as the men and women of this meeting, I should like to suggest some parts of our over-all program which deal mainly with wildlife.

The Council's governing body hopes to create such widespread interest, that where today there is one naturally well-stocked pond, there will be 100; where today there may be 100 streams with harmful pollution, there will be none; where now our state and county volunteer forest fighting organization is inadequate, there will be many more areas with citizens well trained and educated in both fire prevention and suppression; where our forests can be further developed; where occasionally one finds a rod and gun club doing an especially fine job of improving covers, creating better fishing in streams and ponds, persuading cooperative farmers in leaving a little of the fall seed to carry our wildlife through the winter, many more can be so encouraged.

We will increase the use of selective cutting on our farm woodlots and greater use of the wood cellulose left on the forest floor in ground-chips, charcoal kilns and in reseeding areas. Possibly a nursery can be started for the production, at cost, of the American barberry, which is such an excellent grouse food. Probably we can obtain cooperation in the improvement of alder swamps for our native and migratory woodcock. The possibility of increased planting of duck food will be a worthy project. More privately placed wood duck nesting boxes are needed.

Only one of the nine large power reservoirs has met the challenge of sportsmen's clubs in the matter of rainbow trout stocking, giving most excellent natural spring fishing.

Why is the Connecticut River Watershed Council undertaking this great task?

1. Because 1,500,000 people live in its 11,270 square miles of one of the world's richest land areas for industry, agriculture and recreation.

2. Because only at the grass roots level can we achieve the maximum development and usefulness of such a watershed.

3. Because self-help watershed development programs can do a better job at a fraction of the cost.

4. Because research coordination and education are needed, hence, the preparation of a new four-color economic atlas, "Your Valley—Your Future."

5. Because President Eisenhower has said, "we need resource development and we need it on a river basin basis."

6. Because annual flood damage is estimated at $6,000,000 a year.

7. Because a four-state pollution compact is seeking public support.

8. Because 1,640 miles of drainage ditches and field diversion terraces are needed.

9. Because stream bank erosion exists on hundreds of miles of its river system.

10. Because contour stripping is needed on half a million acres of farm land.

11. Because the pasture land has 151,000 acres of needed improvement.

12. Because there are 138,000 acres of marginal farm forest land too steep for tilling, too rugged for pasture, too remote for economy, which should be converted into forests.

13. Because over 4,000,000 acres, or half the watershed, needs improved forest management in a time of stumpage drain.

I was fishing one cold early April 15th morning, when our trout season had opened, on a small stream tributary to the Connecticut in Franklin County. The river mists hung low. I was conscious of a great motion in the fog above me. Ducks were moving north. Later, as I left the stream, I discovered why the wingbeat of thousands of ducks had been so noticeably near. There, in a large 10-acre field adjoining the brook, were the rotting and broken hulls of leftover pumpkin and squash full of seed from the previous fall. The ducks knew!

In this great beginning of the Connecticut River Watershed Council, we cling to the belief that the people of the valley should not only set their house in order at the "grass roots" level, but that they should be way in advance of federal and bureaucratic policies and controls and projects. It would be a splendid thing if the directors of all wildlife organizations could outline for publication and distribution to the thousands of people who are relying on us, educational information which would help and urge each and every one of them to play a part in this important program. Much has been done. Great knowledge and research and accomplishment is a matter of record. What we need is the encouragement of the success in other areas, so that we too in the Connecticut Valley may have the best, do our utmost, and in turn set an example for some other region.

CONCLUSION

We believe:

No man should fear over-organization in the field of conservation.

When water seeks its own level according to nature's law, many divergent interests become involved and require coordination.

In conservation, specific projects at the local level are a must.

Benefits must exceed the costs.

For many purposes, water must be cleaner than that we drink.

Reckless forest cutting practices are damaging to the quality and volume of water flow.

In wildlife, sportsmen are entitled to harvest only the surplus, and we must create the surplus.

Pest control policy should be set on a multi-state basis.

Water must be kept on the land and in the soil as long as possible.

A resources inventory is essential to a long-range program.

The important job is to sell the public on watershed control.

Such an organization as the Connecticut River Watershed Council can be of great aid to all conservation interests.

DISCUSSION

CHAIRMAN SHIRLEY: Thank you, Mr. Tufts. The papers by Mr. Tufts and Mr. Peterson are now open for questions and discussion.

DR. ROLAND MCCLAMROCH (North Carolina): Mr. Chairman, I would like to ask Mr. Peterson if his published paper will have those authoritative references which he referred to.

MR. PETERSON: Yes, they will.

DR. HUGH BENNETT (Virginia): Mr. Chairman, I was impressed with the last statement just made, that we must educate the public. Could I make a statement along that line?

CHAIRMAN SHIRLEY: Sure.

DR. BENNETT: I agree that we must educate the public with respect to what needs to be done in the control of floods and control of siltation, and things which must be done for the benefit of the wildlife. But something else needs to be done, in addition to that; and I think it is getting time that we wake up to that fact. We have to educate not just the public; but we have to educate our leaders. They make the laws; they make the provisions; they make the final decision as to whether a dam will be built at Tuttle Creek. We do not. We talk among ourselves; I think we are pretty well convinced, among ourselves, that we need the things which are being done here. We need to do some more convincing, and there are a lot more things—Mr. Peterson did not have time to cover all of them—which we need to tell our leaders. If we do not tell them and educate them, they can come back and say, later on: "Well, why didn't you tell us?" We have not told it adequately.

In the first place, we have found out, through scientific methods, that at least three-fourths of the flood-control damage takes place on the upstream, small streams up on the watershed where the rain is falling.

Another thing we need to tell our leaders is that flood control should begin at the very uppermost part of these upper watersheds, and go down stream. If we do that, we can determine, perhaps before they build these great dams down the stream; and if it is decided that they need some sort of dam down there, maybe, instead of being 250 feet high, it needs to be only 220 feet high.

Another thing which I think we need to tell them is that these valley authorities should be decided upon by the people who live in the valleys themselves, not imposed upon them by some directive from Washington.

The Soil Conservation Service has done the best it can on these little watersheds. We knew, quite a long time ago, that, during the record flood on the Ohio River in January, 1937, something over ten inches fell on the watershed where we had installations on comparable watersheds. We lost 75 per cent of all the rainfall on cultivated land; on a similar watershed, where there was a good cover of forestry, we lost only approximately 35 per cent. That ten inches of rainfall mostly came in the City of Davenport.

Figures like that, determined quantitatively and not just qualitatively, should be carried to our leaders in Congress; and we are the people to do it. If we sit around and keep on talking to ourselves, we are not going to do it, and the people are not going to take charge of these things as they have on the little watersheds right at the grass roots. The conservation program is being carried on by the people through soil conservation districts; the Soil Conservation Service has already decentralized; it has carried its work out as close to the field line as it can get it, working with the people who live in soil conservation districts, set up on their own volition by their own state legislators, and directed by the farmers. What the Service does is not in the form of a directive to the farmers; they do not call farmers into a room around a comfortable table and tell them: "You do this and you will control erosion; you will control siltation; you will reduce the run-off in floods."

But they go with the farmers at their request and work with them out in the fields and the pastures and woodlands, and up and down these 200 million gullies. I did not take out a thing there, but I took it from a survey of the United States. We classify the whole United States, working in cooperation with the best soil specialists we can find in each state.

We have a lot of information like that, not guesses but actual information. We know a lot of things; I know we are not going to get flood control any time soon unless we begin to side up on these little watersheds and work down the streams. I do not think we are going to have very big floods on the Kennebec River. There are some narrow, closed valleys in West Virginia where we do have floods, and they may need some sort of dam, a little bit bigger than they may let the Soil Conservation people furnish technical assistance on. That will be determined on the basis of the best information we can get.

So let's talk to some others besides ourselves.

CHAIRMAN SHIRLEY: Thank you very much.

MR. GENE TURBIN (Oklahoma): Our Senator, Mike Monroney, has introduced in the Senate of the United States today a bill which suggests the appointment of a committe to study the effect of watershed control.

CHAIRMAN SHIRLEY: If eternal vigilance is the price of peace, perpetual education is what we need. I wish again to thank our splendid speakers for the excellent program they have given us this afternoon, and especially to thank all of you for your patience and your avid interest in this very interesting program.

GENERAL SESSIONS

Wednesday Afternoon—March 11

Chairman: G. W. Malaher[1]
Director, Game and Fisheries Branch, Department of Mines and Natural Resources, Winnipeg, Manitoba

Vice-Chairman: P. W. Schneider
Director, Oregon Game Commission, Portland, Oregon

LIVING SPACE FOR WATERFOWL

INTRODUCTORY REMARKS

P. W. Schneider

Ladies and gentlemen, it is my privilege to call to order the final general session of the Eighteenth North American Wildlife Conference.

The title of this session is "Living Space for Waterfowl." I am sure this presents a stimulating challenge to all of us interested in the migratory resource of waterfowl.

I should like to say, on behalf of Mr. Malaher, who was scheduled to participate as chairman and conduct this session, that he extends his most serious regrets that he was unable to be here. I shall attempt to conduct this meeting on his behalf, and I am confident, with the stimulating papers scheduled for this session, that you will find them most valuable.

In order that we may get started on schedule, we are going to start without further ado. It is my pleasure to introduce to you, for the presentation of the first paper, Mr. W. Winston Mair, chief of the Canadian Wildlife Service. Mr. Mair.

[1]In the absence of Mr. Malaher, Vice-Chairman Schneider presided.

DUCKS AND GRAIN

W. WINSTON MAIR

Chief, Canadian Wildlife Service, Department of Resources and Development, Ottawa, Canada

Much has been said in recent years about the waterfowl depredation problem; yet one has the feeling that there has been a reluctance to admit the real significance of the way in which the situation is developing. As the continental waterfowl population grows in size, so does the volume of complaints from agricultural interests; and the outcry becomes constantly more organized and more insistent. It is past the time when we should shake off the blinkers and face squarely up to the situation. It is high time for us to take stock and ask ourselves, "Are ducks and agriculture compatible on the Canadian prairies?"

Crop damage by waterfowl in the three Prairie Provinces of Canada has occurred to some extent ever since the region was first opened to agriculture. It has, however, worsened since 1900 with the fifteen-fold increase in acreage devoted to cereal crops, with the advent of certain new agricultural practices, and more particularly recently with the notable increase in waterfowl populations. It is clearly a problem which is inescapable, and one which we must recognize and meet. Our failure to do so may result in one of the greatest blows suffered by wildlife conservation during this century—namely, loss of the sympathy and cooperation of our farmers.

I need not emphasize the importance of the agricultural areas of the three Prairie Provinces. All of you must be aware of the tremendous upsurge of waterfowl populations which these provinces experienced during the last two favorable years—that is, climatically favorable for waterfowl. The increase in certain areas last year was phenomenal and brings home to us once again the truism that wildlife thrives where good agriculture flourishes.

The question may be posed, however, whether damage to crops by waterfowl is, or has been, significant. When one farmer has, over the last seven years, lost the equivalent of one full crop, and his normal crop yields from 125,000 to 150,000 bushels of wheat, then that loss is significant. And such loss is a relative thing. Loss of a thousand bushels of grain in one year can be equally tragic for the small farmer. No industrialist or business man would write off without protest losses of similar proportions. Can we then, as wildlife administrators, fail to take cognizance of this problem, and fail to take action? Can the sportsmen and the aesthetes ask the farmers to accept these losses cheerfully? The answer is "NO." We must find some acceptable solution.

The farmer has been a most valued ally in the fight to bring back waterfowl from the doldrums of the 1930's. The small breeding stocks which we so carefully hoarded were raised on, or near, the properties of the farmers. Farmers ploughed around nests and raised their mower knives to avoid destroying them; they carried ducklings to water; they shot crows and other predators, and they worked shoulder to shoulder with conservationists—not so much because they were duck hunters as because they were inherently sympathetic to the need and to the work being done.

Today, what reaction do we find? We have been told that many farmers now plough waterfowl nests under and drive through them in the hayfields. Some, so it is reported, even puncture eggs in nests so that the females will continue futile incubation when they should be renesting. Protest meetings in some of the main depredation areas have called for spring shooting or year around shooting for farmers, and suggestions for oiling or chemically treating sloughs have been put forward. Farmers, harassed and exasperated, have declared ducks pests, and the ominous word "extermination" has been used.

We recognize that a cycle of favorable years has brought both good crops and high waterfowl populations. But this state of affairs will not continue forever. The day may well come when we will have to go hat in hand to the farmer to ask again for his cooperation in restoring diminished waterfowl populations. It he going to welcome us with open arms; can we again expect his full cooperation? The answer to that question lies in the action that we take today.

Fundamental to any workable approach to the problem is recognition of the fact that there must be an optimum level of waterfowl populations concomitant with intensive agricultural practice. We have been alarmed by the low population levels of the thirties, and quite rightly have turned all hands to the task of recovery. But perhaps we have become too absorbed in our task and have failed to recognize the limitations, not of our wintering grounds alone, but also of our breeding grounds. Even in the "good old days" there were limits to waterfowl population increase; today such limits still exist, but at a much lower level, determined by a different set of conditions. We have first to discover within what range the optimum of waterfowl populations lies, and then, if we find that current populations surpass that optimum, our duty is to manipulate the harvest in an effort to bring our stocks to the desirable level and maintain them there.

Clearly stated, then, our policy should be to manage our waterfowl in such a way that serious damage to crops is eliminated, while at the same time ensuring that no game species is reduced to such an extent that reasonable opportunities for hunting it cease to exist. Our plan of attack must be three-pronged, embodying research, management, and extension work.

We may well blush to state that today in North America (not only in Canada) we know a good deal about procedures or methods for increasing populations of waterfowl, but we know little about the methods of manipulating and controlling them. We need more research on the ecology of our prairie waterfowl: It should encompass study of habits and depredation patterns, native foods and new food habits. We need to know whether the ducks causing damage, or being hunted, in any specific area were hatched in that area. We must know what spring population is necessary to ensure optimum reproductive success under ideal conditions, and what percentage of the autumn population may be removed safely. We must study agricultural practices and crop-protection scaring techniques. We must carry out more research into the nature and scope of the effects produced by our various hunting laws and restrictions. It is difficult to draw a hard and fast line where research ends and other functions begin, but the Canadian Wildlife Service has already begun studies in order to find some of the answers which are needed.

Management may require a variety of activities. New and improved scaring techniques of demonstrated worth must be brought into use. There will always be a need for them for harvest weather, the great imponderable, will always be an important factor in depredation regardless of the waterfowl population level. It may be essential to establish banishment areas, since there is no benefit in scaring waterfowl from one man's crops if they have nowhere to go but to his neighbor's fields. Research into the inter-relations of agricultural practices and waterfowl habits should provide valuable leads. The change from binder-cutting and stook-threshing to swathing, which is followed in up to ten days by combining, has largely contributed to the heavier grain losses in recent years. It is possible that the use of chemical ripening agents in critical depredation areas might permit crops to be straight-combined and so alleviate the crop-damage problem.

As our knowledge increases we must be prepared to overhaul our legislation, to bring it up to date and to make it practical and sensible in the light of present needs. While the issue of permits to kill crop-damaging waterfowl should be considered a last-ditch resort, nevertheless we must have workable legislation to permit the farmer to protect his means of livelihood. When research has shown the way, we must aim at manipulating waterfowl populations through proper legislative measures. We know that in Canada bag limits are not a sufficiently effective tool, becuse many hunters fail to get their limit; an increase in daily bag limit does not bring a commensurate increase in kill. Nor does lengthening of the season provide an effective answer, since the bulk of the kill is usually made during the first two week-ends of the season, and even this depends to some extent on the weather. It is possible, however, that an increased possession limit would increase the take; this is one of the points which should be investigated.

Now we come to extension work, or "public relations" if you will. Research and management cost money—the taxpayers' money—and if we are to carry out the necessary work we must let the people in on what we are now doing, and hope to do in the future. An informed public is our greatest asset. The lessons learned from research must be translated into practice, and this requires the cooperation of the public and, above all, of the farmer and the sportsman. In particular, it is an essential part of our function to ensure that the waterfowling public understands the basis for extensions or restrictions in hunting privilege, and supports either step wholeheartedly. Your research, and your plans based on it, may be first-class, but if you can't put your plans into effect because of public opposition, your work is just wasted.

What cooperation can we expect—what cooperation do we need—from agriculture? We may, I think, reasonably expect that the farmer will accept the principle of maintaining optimum waterfowl populations which may, under certain conditions, cause his interests some damage. Few farmers wish to have waterfowl entirely exterminated and the majority, if they feel that we understand and are tackling their problem, will be ready to meet us halfway. They will not mind contributing some grain as an equitable share of the cost of solving the problems. They will take the time and trouble to erect scaring devices when necessary. I repeat, that is what we may reasonably expect of the farmers; but first, we must do some serious missionary work among them—not to save their souls—but to prove to them that we understand and respect their point of view, and to sell them on the value of wildlife in the national economy. This task presents a challenge to federal and provincial wildlife agencies, who must meet the challenge realistically.

When we have convinced the farmers that we are sincerely working with them, and for them, towards a solution of the depredation problem, then we may look for the farmers to cooperate with us in other directions. We need, and we may expect, their support in promoting a program of multiple land use, with a place for waterfowl; we may even prove to them that certain areas are more wisely retained as good marsh than converted into mediocre farm land.

What of the sportsman's place in this extensive program? He is a prime and essential figure in our plans. He takes the most active interest in waterfowl; he is a main source of direct revenue from wildlife, but that is not enough. Sportsmen as a group must be prepared to take a militant part in waterfowl research and management. They must become conversant with the problems and the needs, so that they can cooperate intelligently in any over-all plan. They must help by submitting kill returns, returning bands, and learning to identify waterfowl, so that, if required, we may achieve a differential kill directed against the offending waterfowl species.

Above all, sportsmen must identify their interests with those of the regulation-making authorities. Too many hunters do not reason out the "why" of the regulations which are aimed at a fair distribution of the sport of waterfowl hunting, not only between this district and that, but also between this generation and posterity. Sportsmen must learn not to ask automatically for longer seasons, bigger bag limits, and so on; they must accept rather the principle of taking only the harvestable surplus of each year, and they must accept and support—and even help to enforce—regulations whose ideal function is to make the whole of that surplus, and no more, available to hunters.

Sportsmen certainly have a place in direct waterfowl management. They could well organize local groups to combat depredation in their various areas. Wildlife field men are pitifully few. Farmers are fewer in these days of mechanization, and in the autumn they are completely absorbed in harvesting work. But the sportsmen—and the nature lovers—can and must be prepared to give their help whenever necessity indicates.

Some sportsmen will say, "But we are always ready to help; we offered our services, and we were turned down!" Here we come up against the problem of the few who spoil farmer-hunter relations for the many. If a farmer must choose between duck depredations and beer bottles, tomato cans and other litter lying on the swaths that will go through his $5,000 combine, he will take the ducks every time. No one grudges the sportsman his fun while doing his good deed, but he must respect the property, the needs, and the wishes of his farmer friends. Whole-hearted and well-guided cooperation by the sportsman in this matter will do more than any other single factor to remove "No Hunting" signs from the prairies.

Time does not permit me to carry this subject further. But let me stress that, in the discussion of ducks and grain—I might almost say "ducks *versus* grain"—we as wildlife administrators would be on an insecure ground if we were not dealing with a natural resource of great significance. Most estimates of wildlife values are open to question, but the place of waterfowl in our economy cannot be doubted. Duck stamp records in the United States and provincial records in Canada indicate that in our two countries we have about two and a half million licensed waterfowl hunters, as well as many additional hunters such as farmers and others who are exempt from the license requirement. The United States Government has in the past spent over twenty million dollars on restoration of waterfowl habitat. The Federal Government of Canada has scarcely dealt with this problem, but the program of farm rehabilitation in the Prairie Provinces, plus the activities of private organizations, has created or restored thousands of water areas suitable for use by waterfowl; the impact of waterfowl upon the economy is no less significant.

Moreover, our doctors and psychiatrists can bear witness to less tangible but perhaps more important benefits conferred by wildlife on the health and well-being of our people.

To sum up, we have in our waterfowl a tremendous asset that deserves and demands a place in the national economy and in the multiple land-use plans for our nations. If it is to hold that place, we must show that we can manage the resource. We must make clear its economic and aesthetic values, and their place in the general life pattern of our countries, and in particular we must prove that we are the friends and co-workers of the farmers, not their enemies. When we have done this we shall have taken a major step forward in preserving our waterfowl for the use and enjoyment of our children and our children's children.

DISCUSSION

CHAIRMAN SCHNEIDER: Thank you very much, Mr. Mair, for that very comprehensive analysis of the international waterfowl picture. I should like to say that the paper is now open for discussion.

DR. J. J. HICKEY (University of Wisconsin): I would like to ask Mr. Mair where the areas of severe depredation are at this time, and what the Canadian Wildlife Service is doing to control it.

MR. MAIR: The depredation in the prairie provinces has been overemphasized perhaps with respect to the extent of the areas involved in the depredation problem. The chief areas have been in southern Alberta, southeast of Calgary; in southern Saskatchewan; the Kindersley area and south, in the Pas and other areas, the Big Grass area and Delta area and so on, in Manitoba. These may not mean too much to many of you; but, while I say that the extent of the damage, as far as area is concerned, has been overestimated, please understand me when I say that it is not necessarily the extent of the damage, in that it is simpler to meet the problems; but it is the extent of the public concern over the problem which must concern us, because people on the prairies are very close together when it comes to the matter of losses, and what affects one affects all of them.

There have been certain activities carried out. This is no new problem and we have been carrying out various activities, both on federal and provincial levels. I will not bother going back over work which has been done, but one of the steps which we considered most hopeful in the picture was the calling of a conference at Saskatoon last fall, in October, when the provincial authorities from the three prairie provinces met with the federal authorities in a frank, open discussion. We also had the enforcement people there, and we laid all our cards on the table, discussed the thing thoroughly, and came away with more or less complete unanimity of thought.

It was decided that the field of management and public relations should largely rest with provinces and that the field of research, plus some public relations activities, should rest with the federal authorities, and the federal authorities should provide the necessary information to the provinces to enable them to carry out their public relations.

In this respect then, from our viewpoint, from the federal viewpoint, we have continued the researches which were being carried on, which were organized by my predecessor, Dr. Harrison F. Lewis, and we are now putting one man on full time to carry out the fundamental researches which we have felt were necessary to understand the basic problem involved. This man will be working full time on this project.

From the management viewpoint, we have discussed with the provinces the suitability of having banishment areas; we reached agreements, more or less, on the subject, and our department has given us a green light to go ahead with the proposition. We are looking for suitable areas; the provinces have agreed that they will get the areas for us, and they will see that we have the necessary grain, and so on. We, in turn, have agreed to manage them for the present, employ the personnel, and handle other technical details. I might say that we have had a cooperative agreement with Manitoba for two years, and Saskatchewan is carrying on work of its own.

We have also discussed the legislative measures, and we are in the process of overhauling them. We hope to bring them to something which will meet the needs.

Finally, in the public-relations field, we are, of course, stepping up our program; but, in particular, we are going to make every effort to make the necessary information available to the provinces to permit them to carry on that program.

CHAIRMAN SCHNEIDER: Thank you, Mr. Mair. Are there any further questions?

DR. HICKEY: I do not think all members of this audience, Mr. Mair, understand the term "banishment area." Would you mind explaining that?

MR. MAIR: The banishment area is a tool of management which has been used by the U. S. Fish and Wildlife Service for some time. The idea is to select an area to which waterfowl can be driven or encouraged to move out of the farmers' fields, where they will be permitted sanctuary during the period when the crops still lie in the field. The chief point about them is that, when the necessity no longer exists for the protection of those waterfowl, these banishment areas may be open to normal hunting, and the areas then simply become a part of the general hunting picture. That is how they differ from sanctuary areas, which are inviolable.

AGRICULTURE REACHES NORTHWARD IN CANADA

ANGUS GAVIN
General Manager, Ducks Unlimited (Canada), Winnipeg, Manitoba

Had this Eighteenth North American Wildlife Conference been convened fifty years ago, the title of this paper would have caused little concern, and yet fifty years ago it would have been most timely. For it was at the beginning of the century that agriculture stood poised at the eastern edge of the Canadian prairies for the rush that was to carry westward to the foothills of the Rockies and northward to the coniferous forest. Saskatchewan is an interesting example for, according to the soil survey of that province, there were only some 600,000 acres under cultivation in Saskatchewan in 1901. By 1931 this had increased roughly fifty times to a total of 30 million acres. A similar rush engulfed Alberta, though at a somewhat later date. Unfortunately, then as it is now, it was the best of the prairie waterfowl breeding area which was most attractive to agriculture. Regions of heavier rainfall which made for more secure breeding areas were also much sought after.

Much of the western half of Saskatchewan and southern Alberta is too dry for farming unless irrigation is available, and large acreages are used for grazing, some of which were once farmed and then abandoned. Unfortunately, without help, these same areas are marginal for waterfowl and in most years there is a life and death race between the attainment of flight by the young birds and disappearance of surface water.

Occupancy by agriculture of the arable waterfowl breeding areas of western Canada although not yet complete is nevertheless under tremendous strain.

There are several reasons for this. The first lies with the characteristics of the country itself. The prairie and aspen grove or parkland areas are generally rich in soils and with the modern bulldozer and gang plow it is a comparatively easy task to clear large tracts of land. Secondly, a heavy immigration into Canada and higher prices prevailing for agricultural products have accelerated the pace of land clearing and breaking that, under normal conditions, would have been much more leisurely.

Today the northern fringe of agriculture impinges on the coniferous forest area, and any expansion further northward can only be done in selected areas with minor effect on the waterfowl population. Our major concern at the moment lies in the prairie and aspen grove or parkland belt.

When settlers first moved into these areas, lakes, sloughs and potholes were in abundance. Loss of much of these breeding areas has been a major blow to waterfowl. It is no supposition that these grassland ponds and sloughs were favored waterfowl habitat, for breeding birds still cling to them, wherever they exist, in populations far exceeding anything found elsewhere.

Traveling through these areas today and trying to compare them with the older large-scale maps provides a shock that cannot adequately be described. The grass is all gone and remaining sloughs and potholes are cultivated to the water's edge. The wet years since 1949 have, to some extent, replenished and replaced many of these older areas, and waterfowl use them, but always with the risk of nest destruction by agricultural activity. While there were, no doubt, good years and bad, years of drought and years of unseasonable cold or great sweeping fires, yet from these prairie and parkland ponds came the great surge in waterfowl numbers of bygone years.

The coniferous forest, on the other hand, even in the primeval state, has never offered the same extent of waterfowl breeding habitat as the prairies and aspen parklands. Here there are few open grassy ponds and continually wet conditions speed succession in low areas through acid waters to cattail, lily pads, and muskeg, spruce and tamarack swamps. Waterfowl habitat does occur, however, in larger blocks surrounded by nonproductive swamp and forest. A typical example of these larger blocks occurs at the deltas of the Saskatchewan and Athabasca Rivers. In their own right these blocks produce a heavy quota of waterfowl and the loss of any of them would be a serious blow to wildlife.

Many of these areas, however, are safe in their present remoteness. Others are dependent on the foresight of provincial and Dominion authorities if they are to continue to produce waterfowl. Fortunately, most are still Crown Land and under government control. It is therefore possible to plan their future much easier than if there were private landowners to be dealt with.

The aspen grove or parkland areas present an entirely different problem. Much of these areas have already been sold or leased to agriculture and the saving of existing waterfowl habitat becomes vitally more important with each passing year. Governments of the Prairie Provinces realize this and, in Alberta and Saskatchewan, they have set up what is known as Water Stabilization Boards. These are comprised of technical men from the provincial Governments and Ducks Unlimited. Its purpose is to plan and direct water development projects which would maintain the water levels of lakes and streams at heights sufficient to maintain a healthy and stable life for fish, waterfowl and other wildlife. One of the most valuable aspects of this board is its close association with the agricultural departments. With roads rapidly pushing northward into the parkland areas, it will only be a matter of time before much of the mixed woods and coarse grasses which now cover the area are replaced by waving fields of grain. Greatest danger to wildlife is denudation of forest cover protecting headwaters and wet lands, the drying out and draining of swamps and muskegs and the inevitable result of streams deteriorating from permanent to intermittent flow. To some extent, this has been offset by the stabilization boards which forbid the sale or disposal of land for 300 feet back from the shoreline of any stabilized area.

On the prairies themselves, much has already been done by the provincial governments, the P.F.R.A. and Ducks Unlimited. This has mostly been the correction of past mistakes and while a heavy restoration program still remains to be done, enough has been accomplished to significantly influence waterfowl production.

In Manitoba although no stabilization board has yet been set up, the work done by the Provincial Government in this province in the development of muskrat areas and the setting up of registered traplines is in effect, similar to the water stabilization work. This type of development is also carried on under government supervision in the province of Saskatchewan. The results of this type of work are readily manifest when we compare the figures of beaver and muskrat production. In Manitoba, since the advent of controlled areas, the beaver population has been brought back from virtually nothing in 1942-43 to a population level with a permitted harvest of 27,000 pelts in 1952 with a value of approximately one million dollars. The muskrat crop, under the same type of management has, on the average, more than doubled in the past number of years. The story is the same in Saskatchewan. Beaver increased from a take of 473 in 1944-45 to 14,100 in 1950-51. Muskrat production more than doubled in the period 1946-50.

The value of this work to improved waterfowl production is evident when the intimate relationship between muskrats, beaver, and waterfowl is considered.

The advancement of agriculture into the remaining arable waterfowl breeding areas should not cause us too much alarm, provided proper wildlife management keeps pace with this advancement. Most of our waterfowl are extremely adaptable to changing conditions and will do very well in the midst of farming provided the necessary requisites are left for them to set up housekeeping.

What, then, should we do so that present waterfowl populations may be maintained and even increased? First, let us hold firm to what we have, particularly to established and flourishing marsh areas. These should be built up where necessary to insure permanency. Drought will again sweep across the prairies and from the northern areas and aspen parklands must come the core of waterfowl production during this period. The value of the more permanent marshes and ponds of the aspen grove area which fringes the prairies on the north and east and the long grass prairies stretching from Manitoba down into Minnesota and Iowa cannot be overemphasized. Drainage of these areas is utmost folly. Secondly, let us develop new breeding areas on the prairies where topography and land use make this possible. Suitable areas of this type are to be found in all three prairie provinces. Much of this is range land but can be made to produce both waterfowl and cattle provided means of developing permanent waters are available. Often this is possible through proper use of natural run-off or waste irrigation water.

Development can follow two general lines. The first is to establish larger areas primarily designed to provide breeding space for waterfowl. These should be made as permanent as possible but always keeping in mind successful plant growth with water depth. Secondly, smaller deep areas should be built whose prime purpose is salvage. Recent investigations have shown waterfowl broods to be very mobile, moving frequently from pond to pond. It has further been shown that there is a definite movement to deeper areas during late July and August when water conditions are most critical. Last year in some pot-hole areas breeding populations were as high as 100 pairs per square mile. Establishment of permanent waters, however small, through such areas of high production is imperative.

Since Ducks Unlimited started operations in 1938, much has been accomplished on the Canadian breeding grounds, yet a tremendous amount still remains to be done. The pressure on available breeding habitat during the past few years has been acute. It will be much more so during a dry cycle which is bound to come. The cooperation of every sportsman, farmer, landowner and government is therefore necessary in order to save and build against the advancing march of time.

DUCK CLUBS FURNISH LIVING SPACE

JOHN M. ANDERSON
Superintendent, Winous Point Shooting Club, Port Clinton, Ohio

As Aldo Leopold would say, "There are some who can live without wild ducks, and some who cannot." It is my good fortune to work for a group of men who cannot. I live in the middle of a marsh; part of that strip of marshland that separates southwestern Lake Erie from the Lake Plains. French trappers who first occupied this region named it the Black Swamp. But, as northwestern Ohio became replete with agriculturists and engineers, this bigger-and-better society promptly labeled it a "useless" swamp, and proceeded to drain it. This paper is an attempt to point out the values—economic, social, esthetic, of that remnant of land still under water; and to give my personal, private opinions on why and how it should be preserved. May I repeat, the opinions expressed are my own, not necessarily those of my employers or any other group.

We, who cannot live without wild ducks, must first of all acknowledge two facts:

1. We are the minority.
2. The majority regards any land which is too wet to plow, but unsuitable for swimming or motor boating, as useless.

There is abundant evidence to support this contention. For example, Dr. Robert M. Salter, chief of the U. S. Soil Conservation Service, said last year in Des Moines, Iowa, "If price were no factor, we have millions of additional acres in this country that could be put into agricultural use. . . . Along the East Coast and Gulf States, there are at least 10 million acres that could be drained. . . . Furthermore, on hundreds of thousands of farms throughout the country, there are corners or patches of idle wet land . . . that could be drained and made productive."

Has man become so stupendously wise that he can classify a prairie slough as idle because it does not produce what he calls a "cash" crop? That classification may be good enough for those who see our land as a machine for grinding out food; but it is not good enough for me.

As additional evidence, here is a clipping from the Cleveland *Plain Dealer*: "Trenton, New Jersey, April 9, 1952 (Associated Press): New Jersey farmers were told recently that the soil of the United States is capable of producing 'food in abundance' for one billion people.

"Dr. Firman E. Bear, Chairman of Rutgers University Soils Department, said the actual production problems of growing enough food for that many people would be very serious . . . land would have to be reclaimed from the sea, water for irrigation distilled from the ocean, floods brought under control, and every acre of land conserved. . . . There are only about 12 acres of land for every person in the United States, and over half of this is swamp, desert, mountain, and lake."

Now, in fairness to Dr. Bear, it should be stated that he probably had no intention of being quoted on "food in abundance for one billion people." Possibly he made no such remark. But, nevertheless, that is what the Associated Press saw fit to report. And that is what Mr. Average Reader will remember. And, putting two and two together, Mr. Average Reader will take for granted that it is only a question of time until "scientific farming" has taken over every acre of swamp, desert, mountain and lake; that all this is fitting and proper, part of the natural scheme of things. And this business of worrying about the conservation of soil, water, and wildlife is a bunch of hooey.

Another man who is quick to go along with this type of thinking is the real estate developer. For example, a large area of marsh on southwestern Lake Erie known as Reno Beach was drained and dyked during the drought years. But the protecting levee was smashed during a northeaster in 1943, again in 1948, again in 1952, and part of it is under water today. But, with your tax dollar and mine, the U. S. Army Engineers are driving steel piling, and pumping out the water so the cottage owners can hurry back and chase out the muskrats, turtles, and ducks.

The good old Army Engineers, known in Congress as "the lobby which can't be stopped!" For what congressman would dare vote against the uniformed beaver's demand for more and more millions for more and higher dams in that sacred name of Flood Control? The Department of Agriculture has good evidence that watershed management alone (*i.e.,* temporarily holding the water on the land where it falls), without costly mainstream dams, can stop all flood damage on most watersheds. But, last year, Congress appropriated $255 million to the Corps for *general* flood control work, and less than $8 million for watershed management by the Department of Agriculture. The cart is about three lengths ahead of the horse.

The engineers may know how to build magnificent dams, but they are not ecologists. If we are going to prevent the floods—and, incidentally, save the sport of duck hunting—men with a solid background in ecology must be given the responsibility for flood control work. Building a bridge or an airstrip is one thing, but preventing floods is an entirely different matter.

Unfortunately, the engineers have an ally; in fact, an army of allies. I mean the army of social planners and do-gooders who cheer wildly over the prospects of our land producing food in abundance for one billion people. Lieutenants in this army write articles for the *Reader's Digest* about the glorious prosperity that will result when our greatly increased population demands more Fords, bathtubs, television sets, diapers, bread, and milk.

Well, if our popuplation reaches one billion, they will all have to eat. But, thank God, I won't be around to watch them. Having stretched, dried, aged, sexed, and weighed some ten thousand muskrats in the past four months, it is perhaps only natural that I keep comparing muskrat populations to human populations. Thanks to wildlife research, we have a fair notion of what happens when muskrats become overcrowded. They are thinned out by disease. In the muskrat, however, we do not call it influenza, but Errington's disease. Likewise, starvation. "Eat-outs" are well known to marsh men in Louisiana and Maryland, as are famines in China and India. And when overcrowded muskrats fight each other, we call it intra-specific strife, instead of war.

Now, then, do we dare suggest that the human animal is a product of *his* heredity and environment, the same as a muskrat is? That similar population controls might exist in both species? If we are going to save the sport of duck hunting, we'd *better* suggest it! Furthermore, we'd better convince a lot of people that it is true.

But, if we do, certain elements of the press will scream, "Pessimists! Calamity Howlers! Neo-Malthusians!" Just as one editor of *Time Magazine* (Nov. 8, 1948) screamed at William Vogt after his book, *Road to Survival,* was published. *Time* will quote Dr. Salter, saying, "On hundreds of thousands of farms throughout the country there are patches of idle wet land that could be drained"; the editors will not ask themselves whether or not drainage of these small reservoirs will contribute to the terrors of the floods we see in our land every spring. The editors will reiterate their faith in the ability of the Army Engineers to build the levees higher, and higher, and higher.

If we are going to preserve living space for waterfowl, we must undertake to change the editor's mind; or make him scream so loudly that he becomes too hoarse to be heard.

Now, in contrast to the Army Engineers and their efforts at the Reno Beach drainage project, let us look at the lands owned by the Winous Point Shooting Club. Both areas were dyked in during the drought. But, at the duck club, the water was pumped into the marsh—not out. Ducks and muskrats, instead of summer cottagers, were encouraged to live there. In more recent years, Lake Erie has stood nearly one foot above mean level, having gone from drought to flood stage. Levees were smashed, both at Reno Beach and at Winous Point.

But, at the duck club, the task of rebuilding was undertaken, not by Army engineers, but by duck hunters in an effort to provide habitat for ducks during the reproductive, over-wintering, and shooting seasons.

Fifty years ago, Sandusky Bay was a haven for waterfowl. The water was clear, and supported luxuriant growths of wild celery and other aquatics. Today, Sandusky Bay is so turbid that a Secchi disc often disappears at a depth of six inches. Wherever this muddy water is allowed to stand in the Winous Point marsh during the growing season, food plants such as Walter's millet, nodding smartweed, rice-cutgras, and coontail are doomed. In combatting these conditions, I daresay this one duck club, over the past 98 years, has spent more money to provide living space for ducks than some state game departments have.

It can be argued, of course, that when the State provides habitat, it does so for the benefit of all hunters, whereas the privilege of *shooting* ducks at the club is restricted to members and guests. But, show me the land which provides both unrestricted use by waterfowl and unrestricted use by man. On most state and federally owned marshes, there is either rigidly controlled public hunting or no hunting at all. On those breeding grounds in North America which still produce ducks in significant numbers, climate, geography; and economics restrict the use of that land by man. We may as well face it; ducks and restrictions are as inseparable as ducks and water.

But modern game management aims at multiple use of wild land. And so it is at Winous Point. The growing army of bird watchers, such as the Columbus Audubon Society, or the Wheaton Club, make annual visits to the marsh. Boats and club personnel are made available to them. Hook-and-line fishermen are allowed free access to the outside dykes. Biology classes from nearby universities arrange for annual field trips. Through cooperation with Dr. Eugene Dustman, leader of the Ohio Wildlife Reseach Unit, Ohio State University, graduate students in wildlife management are encouraged to carry on research there. The Club provides free living quarters, meals at cost, boats, and other field equipment. Two students have completed their studies of waterfowl and muskrats and a third is in progress.

I will be the first to admit that all private hunting clubs are not alike. And one of the most unusual features of this particular club is the fact that no member has, to my knowledge, gotten the director of the Fish and Wildlife Service into a corner and said, "Now look, Al, we've spent all this money for the ducks—now how about letting us use that good old yellow corn for decoys. And let us shoot as many ducks a day as they do in the Central or Pacific Flyways."

Why do they not exert this type of pressure? That is the $64 question. I hope I make it perfectly clear that it is *not* because they think the Fish and Wildlife Service has all the answers (far from it). It is not because they think the regulations are perfect. (The half-mile feeding limit, for example.) Nor is it because they are philanthropists or super-fine sportsmen. It is purely and simply because they are business and professional men who are accustomed to thinking in terms of supply, demand, inventories, and factors limiting production. These factors regulate the price of a ton of steel—they also regulate the bag limit of ducks. Research brought the doctor of medicine respect and efficiency, which is the reason he is willing to sponsor fact-finding in the field of wildlife management.

The man who insists that the way to better hunting is through baiting and increasing facilities for killing ducks is like the union boss who insists that the way to a higher standard of living is through more leisure, by working half as long for twice as much. The matter of *production* is overlooked by both.

The members of the Winous Point Club possess intelligence and integrity, but the reason they do not try to put their own interests ahead of sound flyway management is because they possess information. For example, Mr. Windsor T. White, who at 87 usually kills his four ducks with less than 10 shells, has long been a member of The Wildlife Society. He subscribes to, and *reads,* the *Journal of Wildlife Management.*

At the risk of being called a Pollyanna, I contend there must be many hunters like Mr. White, who possess intelligence and integrity. But, unlike Mr. White, they do not possess information on a flyway basis. They see only what is in front of their blinds! Adequate information on how inventories are conducted, the annual production, factors limiting production, the magnitude of the drainage threat, supply in relation to demand—such information should automatically make many of these men powerful allies of sound management. Without this information, they drift along with the stream. As such, they are not allies. They are useless, or even detrimental, depending upon whether or not they can be persuaded to join certain present-day pressure groups. These pressure groups, unfortunately, are usually bent upon changing the regulations to make it easier to kill ducks in their own county, or group of counties. In some few cases, their claims may conceivably be justified. But, unfortunately for the hunters and the ducks, about all they ever accomplish is to make the duck more vulnerable to his old enemy: the Congressman who appropriates money to drain or otherwise destroy living space for waterfowl.

Said Congressman is not going to change his vote so long as the waterfowl management profession is hampered by misinformation, or by petty jealousy, or by individuals who have been caught violating game laws and are out for revenge, or groups with some other kind of axe to grind.

Nor is said Congressman going to change his vote until his constituents lose faith in the grandiose schemes of the Army Engineers and the Bureau of Reclamation.

And so, as I see it, if we are to preserve our present remnant of waterfowl habitat, our primary task is that of molding public opinion. And in this task, we have some praiseworthy allies; namely:

1. A select few outdoor writers, such as Durward Allen, Arthur Carhart, Mike Hudoba, Jack Van Coevering, Clay Schoenfeld, Harold Titus, George Fichter, Ray Bergman, Elmer Petersen, Harris Breth, and a few others. Most outdoor writers, however, seem to possess very little creative ability, and know nothing about the factors which make ducks live and die.

2. Ducks Unlimited is potentially a powerful ally.

3. The Audubon Society has done a magnificent job in preserving living space, and in making the public conscious of the fact that a bird in the bush can be worth more than two in the hand. I am proud to be a member of the Audubon Society, but I hasten to add (but quickly) that I hope to kill some ducks every fall as long as I live. I think the Society could be much more effective if they would solicit more members from the ranks of those who occasionally like to look at birds over the front sights of the old blunderbuss.

4. But, foremost in the field of getting the right information to the right people, are the privately endowed wildlife foundations. The Wildlife Management Institute, the North American Wildlife Foundation, The Wildlife Federation, Sports Fishing Institute—these are the unsung heroes in the battle. They represent our heavy artillery, trained upon enemy headquarters. Being on the job in Washington, they keep a watchful eye on Congress, and inform us through their newsletters and bulletins of any new threats to our dwindling wildlife resources. The leaders of these organizations can and do speak their minds without fear of financial or political reprisal. This service is a great boon to administrators in various states where sound management policies are opposed by misguided groups with political influence.

For years, professional wildlife men have deplored the fact that, regardless of the wildlife manager's knowledge of the species he is trying to manage, he is limited in what he can do by what the public is ready to accept. And so, when Dr. Eschmeyer wrote ***Billy Bass, Tommy Trout,*** and ***Charlie Cottontail,*** I daresay he did more to promote good fishing and hunting in North America than in all his years with the T.V.A. When Al Hochbaum, sponsored by the Wildlife Management Institute, wrote *The Canvasback on a Prairie Marsh,* I daresay he did more to promote living space for the canvasback than any other single project undertaken by any agency in Canada. Carl Shoemaker says he is retiring. Because of his work in this field, he can no more retire than Aldo Leopold can die.

The idea of being a champion of the common man has gerat appeal to the American mind. But if we are going to maintain living space for ducks, we need a lot of help from the uncommon man.

DISCUSSION

DR. EDWARD GRAHAM (Soil Conservation Service): Inasmuch as the speaker referred to Dr. Salter by name, I should like to make this comment, that the quotation he gave was from an address which was made by Dr. Salter before he became chief of the Soil Conservation Service. To that extent, he has quoted him out of context. I should like to suggest that we use rather, as a reference, the address which Dr. Salter made yesterday afternoon, and comments which he made after his talk yesterday.

MR. ANDERSON: All I can say is that I would be most happy to believe what Dr. Salter said yesterday. I trust that represents his philosophy much better than the speech he made in Des Moines. I shall wait and see. (Laughter)

CHAIRMAN SCHNEIDER: Are there any further comments or questions concerning Mr. Anderson's paper?

DR. HUGH H. BENNETT (Falls Church, Virginia): I used to be chief of the Soil Conservation Service and I know what I am talking about. I have talked about this twice today; I am not going to keep you here all afternoon.

What I want to do is to try to make a little sort of correction, bring about a little clearer understanding of this drainage situation. I have been very much impressed by what has been said during this meeting about the drainage situation. I heard Dr. Salter's talk yesterday; it was different from the other occasion. But that is not so much what I want to talk about here. The implication has been left here—and it is not going to do any good, I know from experience—that all the drainage which has been done is detrimental to wildlife.

Now, if we are not going to be realistic and go ahead and talk among ourselves and make that major mistake, we are not going to get this drainage thing worked out like it should be worked out and drain the land which should not be drained. I think everybody will agree that we should not drain these potholes up there; but we will all work together in cooperating to prevent that, and I think we can do it.

But the drainage which is being talked about a great deal is not really drainage; it is the improvement of already drained land, a lot of which was drained during the American Revolution by slave labor, and you can see it on a short drive from here in southern Maryland, in Delaware, and New Jersey. The ditches are filled up, but they are still cultivating the land every year, and all but one per cent of the so-called drained land relates to land like this.

I think these are the experiences. The water which accumulates in slight depressions on these lands is simply taken off by this improved drainage of already drained land, most of which is cultivated every year. Stopping that is not going to do the country any good. They ought to define that kind of water by law. We ought to classify all our land in this country by law, and we are not going to know what we are talking about until we do.

This water is detached, dispersed water, and it is different, understanding the law as I can understand it—I am not a lawyer—it is quite different from artesian water or water which was accumulated by prior rights, and so on.

It is a simple sort of thing. The farmers are going to keep on cultivating this land. You are not going to improve any wildlife habitat by not taking this water off, or by not taking it off you are not going to hurt anybody but the American people. I do not see why that thing should not be cleared up. When we talk about drainage, we do not qualify what we say. Be realistic. Farmers are going to drain their land; you cannot stop them. I do not think the Congress can pass a law which will stop them, but we can stop unwise drainage if we will cooperate and define what we are talking about and clear up the confusion. That is one of the first things.

I am with you; I think those potholes ought to be protected where they are being drained, and I think the marshes and open water, and so on, should be cleared.

We had a policy when I was chief of the Soil Conservation Service, and I think it still prevails. We had a lot of points which we told our boys to recommend to the farmers. We do not want to operate by directive but by cooperation. It is down through the districts that the farmers make the final decisions. If we are not going to cooperate, we are not going to get anywhere on this thing. Let's understand the language of the people.

CHAIRMAN SCHNEIDER: Thank you, Dr. Bennett, for your statement with respect to this challenge concerning the drainage problem which we are all concerned with.

ROLE OF THE STATES IN WATERFOWL MANAGEMENT

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At the last Midwest Wildlife Conference, Linduska (1952) reported that "practically every state in the Union is now supporting waterfowl work of some sort, and the total expenditure for waterfowl by the states and the Fish and Wildlife Service is approximately eight and one-half million dollars." This statement immediately gives us an idea of the scope of our activities in dealing with waterfowl, a natural resource which inherently annually migrates from one end of the continent of North America to the other. Management of such a fluid resource obviously can be achieved only through the best possible coordinated effort on a flyway and national basis.

In the past, in cooperation with the U. S. Fish and Wildlife Service the states have attempted to manage waterfowl by individual effort and through the participation of local citizens in private organizations such as Ducks Unlimited. The magnitude of these efforts by the states has varied considerably. However, in the past few years we have experienced the development of flyway organizations in which our financial and manpower resources and our thoughts have been directed toward a common goal—improved waterfowl investigational work, enforcement, habitat development and management. This recent waterfowl management approach undoubtedly was the product of the recognition of the futility of trying to solve these problems by individual state effort. To better coordinate these efforts on waterfowl work, the Atlantic Flyway states and the Fish and Wildlife Service of the U. S. Department of the Interior documented their "waterfowl management objectives" in 1952. The Mississippi Flyway states are in the process of completing such a document for their region. States of the Central and Pacific Flyways will undoubtedly follow suit.

If waterfowl were distributed evenly throughout the states, it would be possible to enact a simple set of management regulations that would apply universally. The role of the states in waterfowl management then would be relatively simple. Each state merely would have to assent to the regulations and then carry them out. However, the continental waterfowl population is a dynamic force capaple of making sudden shifts, both in distribution and in abundance. We have only to look at the history of waterfowl distribution in Arkansas, an important wintering area of the Mississippi Flyway, to see how the rice culture pulled the ducks from the "natural pin oak" river bottoms to the man-made rice reservoirs (Hawkins, Bellrose, and Smith, 1946). Similar shifts to man-made agricultural feasts have been noted in California, Louisiana, and Texas, to mention a few. Likewise, we know that the continental water supply varies annually within large limits, a phenomenon recalled to us by Dr. Clarence Cottam's paper "Waterfowl at the Crossroads" given at the 1947 North American Wildlife Conference. In 1947 the duck supply was low, yet just this past year, five years later, the supply was considered good.

As groups of states making up each of the four flyways, we have a common objective—better waterfowl management. Yet individual states face vastly different problems locally. Some states contain breeding populations, others merely receive migrants, and others provide wintering grounds.

In order to reach our common objective of better waterfowl management, and not get lost in our individual local problems, we must have a basis or foundation from which operations can start. The first requirement is that each state must have an understanding of the general basic principles of waterfowl management. In broad terms, each should know and recognize where it stands in the flyway and continental picture as to the number and location of waterfowl using its boundaries for breeding and wintering. Spring and fall migration routes and concentration sites should be mapped, appraised, and rated. Data can be secured on these basic topics only through surveys. Some states have already collected much of this information, while others are just starting. Regardless of the stage the work is in, each state must work toward completion of obtaining these basic data, which must be expressed in terms that can be summarized for broad units, such as flyways. Soil types including wet and submarginal lands may be the best way to express results. The value of the information obtained to the national waterfowl coordinating body, the U. S. Fish and Wildlife Service, is multiplied many times by using standardized techniques and means of expression of the results obtained. The standardization of methods of carrying out surveys and expressing results cannot be overstressed. However, we should not feel that present methods are final. They are superior to techniques used in the past, but should certainly be abandoned in the future if something superior in the way of economy or accuracy is found.

To again use Dr. Cottam's words, we are facing the crossroads or a new path in waterfowl management today. For instance, much of the research done in the past, especially banding, on a local scale would certainly have yielded greater returns if it had been conducted on a flyway basis. Through the Flyway Councils we now have the administrative means for coordinating investigation programs on a large scale. There is the door; we need only to turn the knob and enter.

One of the jobs we must tackle immediately is that of determining the extent to which waterfowl wintering, resting, and breeding ranges are either deteriorating or improving. We already know that in the five-year period, 1945-1950, drainage claimed 16 per cent of Minnesota's potholes (Janzen, 1952). What is happening in other states and in the Canadian provinces? What must be done to offset range deterioration? Can it be slowed down or stopped through the use of our own funds, or do states or provinces having the prime range need the help of other states and federal governments?

Basically, the condition of the range is governed by the degree of education or the willingness of the landowner to learn new principles of land management and to apply them to his own holdings. Some people have said that wetlands must be drained to meet the increased demands made on agriculture by human populations, both nationally and worldwide. Yet others have remarked that if all the lands now producing crops were managed with the best soil conservation principles, our present fields would yield more than enough food for us. Possibly we haven't educated enough farmers. Undoubtedly, in some cases, we have paid subsidies to the landowners for questionable measures employed in land management. Perhaps we should be paying them for using good soil conservation practices on the land now cropped, instead of for drainage, in almost any design.

The reason for draining a pothole in a major waterfowl breeding or wintering ground is to use such land for agricultural crop production which nets a significant profit to the landowner who eliminates such a wetland area. It is possible that we may find that the sacrifice an individual landowner would have to make by not draining a pothole would be too much to ask him to bear. Someone will have to reimburse this landowner for not draining his pothole. Is this a problem for the states to decide?

Most certainly, all states must cooperate individually and collectively with all agencies concerned with land use. Measures to protect and improve wetland areas should be integrated into local and national policies of the Bureau of Reclamation, Soil Conservation Service, PMA, Corps of U. S. Army Engineers and similar groups as well as in those of state agencies. Early consideration must be given to alleviating and correcting wetlands damage done by drainage and poor agricultural practices. Similarly, early consideration must be given to measures which partially offset this damage. We must develop and manage for the production of aquatic foods both upland waterfowl areas of constant level pools and those waters with fluctuating levels.

An associated problem also of major importance is the role of the states in regard to public waterfowl shooting areas. There is no doubt but that the present situation is dominated by a reduction of public shooting areas through drainage work, agricultural practices and the tying-up of large blocks of land by commercial hunting organizations and private clubs. If too many hunters become discouraged by a lack of public shooting grounds, the resultant drop in revenue may preclude the adoption of policies which would tend to correct that same situation. In other words, a vicious circle might be created. It behooves the states to give earnest consideration to this problem. Lands must be acquired and developed for public hunting areas. These shooting areas could be integrated into the refuge or sanctuary system on a flyway basis.

Sanctuaries are recognized essentials in waterfowl programs. While the Federal Government has set up a large system of waterfowl refuges, there are many locations where the need for refuges is considered too small for operation. The establishment and maintenance of such areas might well become the responsibility of the states, integrating them into a system embracing the entire flyway. Sportsmen's groups might provide assistance in the development of some areas. It would appear that the states are better equipped to handle the small refuge areas, which often experience changing physical factors.

It goes almost without saying that research must provide the data necessary for sound management. This research, however, should be coordinated in all the states of a particular flyway and, if possible and feasible, on a national scale. Any individual research in a particular state should have as a major goal the part of the project in the over-all waterfowl situation. Federal biologists should be free to conduct projects broad in nature, with the states handling those of local interest, probably with the help of Pittman-Robertson funds. For example, all states should develop statistically sound identical methods for appraising their annual waterfowl harvest.

While nebulous in respect to progress and concrete results, it is obvious that success in waterfowl restoration work depends to a large extent upon educating and informing the public which is served. This phase of the over-all program probably can be handled through existing educational media but the states should make an effort to coordinate activities. It appears the individual states can best handle this problem by working collectively. Under present and past policies, the U. S. Fish and Wildlife Service has recognized the need of pinpointing educational work and left this field largely to the states.

A concept of temporary custodianship should be developed. Because of the migratory nature of waterfowl, no one state can claim the year-around custodianship of any truly migratory waterfowl. In planning a state program for waterfowl, this concept should be kept in mind. Those states which have neither wintering nor breeding grounds must determine what is a "fair share," both in management of lands and of the harvest. Since a major burden of law enforcement, feeding and other care of waterfowl falls upon the states, consideration in the establishment of hunting regulations is recognized. The states have responsibilities to hunters to see they are given an opportunity to share proportionately in the harvest.

As previously stated, the states now have, through the medium of the Flyway Council, the desired opportunity to speak and be heard in respect to the management of the continent's waterfowl resource. The states, therefore, should, after seasons, bag limits, and other regulations are established, and in accord with the concept of temporary custodianship, severally and jointly, with such enforcement personnel at their disposal, enforce all such established regulations.

At the present time we are in the transitional stage of operations. We should de-emphasize the thought of one individual doing basic work on waterfowl, except for local problems that may arise. Individual states should always have personnel available for investigating such local problems at botulism, other diseases, and lead poisoning. The thinking on a specific problem, whether on a national, flyway, or local scale will be done by individuals.

Once a state has made inroads on determining its position in the continental management field by an analysis of its local picture, in terms of the basis principles outlined here, the time will be right for considering how it can help other states. It might be sufficient merely to lend man power for making investigations, or perhaps funds for conducting habitat improvement work will be needed. There are states without breeding or wintering grounds which can increase their own hunting opportunities by assisting those states having these resources improve or maintain them. It would be ironical indeed to create vast breeding grounds in any one state only to find that the inherent nature of waterfowl, expressed in terms of migration routes and habitat preferences, prevented them from ever utilizing such a structure. On the other hand, it would be even more ironical to allow breeding grounds which are now being used to deteriorate because of an economical factor at a time when other states are constructing such an area which would not be utilized.

It appears that the most important role that the states can undertake is to support with all their resources the perpetuation of breeding and wintering grounds, albeit it means the temporary sacrifice of creating a huge shooting ground. But before the states can make such a decision, they need to know whether the present breeding and wintering grounds are being fully used. If despite the rapid loss of these areas through drainage projects there are unoccupied or lightly populated good nesting, rearing and resting wetlands, then mortality may be the major problem and proper hunting regulations are paramount. Obviously the two problems go together. Each one must be a major concern of the states.

In 1948 the director of the U. S. Fish and Wildlife Service addressed a conference such as this and reported "we are striving for a better job of coordination in the whole waterfowl management program" (Day, 1948). The aim of all of the states should be the same today. The difference is that we now have the vehicle, the Flyway Council, as a means of communication among flyway groups of waterfowl workers, as a means of standardizing our methods and expressions, and as a means of completing large-scale projects.

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DISCUSSION

CHAIRMAN SCHNEIDER: This paper is now open for discussion.

MR. FRED GLENNY (Akron, Ohio): One of the problems which we have encountered in Ohio—and I presume it is encountered in many other states—is that of ownership of water by political subdivision lower than the state. In the City of Akron, for example, a tremendous water area is owned by the city. Hunting and fishing in that vicinity, or on the lands adjacent to it, and the waters of the city proper, are prohibited. If the state is able to obtain the rights to open those waters to public hunting particularly, shall we say duck hunting, then you may have a partial solution to public hunting grounds. I am afraid, as it is, you will find tremendous areas, which could otherwise be hunted, out of bounds.

CHAIRMAN SCHNEIDER: Thank you, sir.

DR. J. J. HICKEY (University of Wisconsin): I was interested in the reference in the paper to the establishment of Flyway councils as the means of integrating the research workers in the waterfowl field.

I might point out to my colleagues in the universities that, to my knowledge, not one of them has even been invited to a council meeting. We know nothing about what has been going on in that area. One university I know of has as many as five students working every summer in Manitoba. Perhaps the states and the federal agencies are doing research in this alone.

CHAIRMAN SCHNEIDER: Mr. Swift, do you have any remarks to make?

MR. SWIFT: Joe, I do not know whether I can answer your question exactly, but I can explain the creation of the Flyway council. I believe the West and Central Flyways have had a council for some years, and the Atlantic has had a council which did not include all the states.

At the Rochester meeting of the International, by adoption of a policy of the International, it was decided to create a Flyway Council, consisting of the state administrative authorities.

In some of the Flyways, there has been an organization of research men under the blessing of the states, which have been attempting to coordinate their efforts. This was an attempt to coordinate the research work with the administrative work, so that both sides would be on the team.

There was some misunderstanding at the start, or possibly a few inhibitions that administration was going to take over and not give due consideration to research. But I believe that has been definitely cleared up.

There have been various types of councils which have given the Fish and Wildlife Service and the states support, but the Flyway Council was organized basically to bring those people into an organization who had definite responsibilities to their states and their citizens from the standpoint of waterfowl, which came through their enforcement of the laws. After a great deal of thought, it was felt by the 48 states that this was the way to coordinate properly the responsible authorities across the United States.

Now, I appreciate that maybe the universities have not been brought into this; but our research men are as much a part of the team as anybody else. I believe we more or less have left it to the research men to work out the pattern they are going to follow on research in coordination with the Fish and Wildlife Service, so that they, in turn, report back to the administrators what the facts are: then, in turn, the administrators deal with the Fish and Wildlife Service through the National Flyway Council on the matter of regulations.

Does that at all answer your question?

CHAIRMAN SCHNEIDER: Thank you, Mr. Swift.

MR. JOHN H. BAKER (President, National Audubon Society): May I, with your permission, ask a question of Mr. Mair?

Would you care to tell us what you think of the possibility of practical application of commercial insurance in meeting the problem of duck depredation and whether, if you do feel it has practical application, you think it would tend to reduce the need for killing controls?

MR. MAIR: Ladies and gentlemen, the problem of insurance to cover specifically duck depredation has been discussed in Canada, as an inquiry into it has been made in Alberta. So far, we have not had any definite answers as to the result of this inquiry. However, in Saskatchewan, they are definitely taking steps forward to establish an insurance scheme to cover depredations of all types, including waterfowl depredations. We are most hopeful that this will be a useful tool. I do not think that we need hope that it will be the answer.

However, I would like to point out some of the difficulties involved. Anyone who has lived in the prairies knows the farmer, knows that he is a gambler from the start anyway. We know, from experience with hail insurance, that he would just about as soon take a risk in not bothering to pay the hail insurance as to put up a few cents per acre and get back some return in case he is hailed out. Now, I would think there is reason to suspect that the same situation will exist with respect to waterfowl depredation.

The other problem may be that, because the extent of the depredation area is reasonably small compared to the over-all area of the prairies, there may not be sufficient persons who would take out insurance to make it practical.

However, I do think it has much merit. I might say that it is the Saskatchewan Government which is underwriting this insurance scheme; and I can tell you we are all watching it with much interest. We hope it will succeed. If it succeeds, I do think it will contribute very considerably to our solution of the problem. It will at least give the farmer the feeling that he has some recompense.

The point I would like to get across is that even if it is successful, I do not think we need believe that it is going to be the answer. To put it in dollars and cents, the farmer is not going to be too happy to take possibly ten dollars per acre when he had a 50-bushel-to-the-acre crop, and wheat remains over a dollar a bushel.

With hail, he takes it because he cannot do anything else about it; but, with ducks, he thinks he can do something else; he can pick on us.

A BROADER WATERFOWL MANAGEMENT PROGRAM

JOSEPH P. LINDUSKA

Chief, Branch of Game Management, U. S. Fish and Wildlife Service, Washington, D. C.

Ducks are big business—a big business that has grown steadily over the past few decades. And the end is not yet in sight. Duck-stamp sales are a good measure of the mounting interest in waterfowl hunting, and the picture is this: From 1934, the first year of the Duck Stamp Act, to 1948 the number of stamps sold increased more than threefold. In 1949 an amended Duck Stamp Act increased the price of stamps from one to two dollars. If this was any appreciable deterrent to sales, the statistics fail to show it. The total of duck stamps sold in Fiscal Year 1951-52 reached an all-time high of well over two million. Membership in the duck hunting fraternity continues to mount.

And as consumer numbers and demand for this waterfowl commodity increase, the raw materials for production become ever scarcer. In competition with economic demands on the land, wildlife patently holds a low priority. Ducks are no exception. You have heard today, as you have at other conferences, of agriculture's inroads on "Living Space for Waterfowl." Inroads that on one hand reduce the production potential and on the other make a plague and a pestilence of the remaining birds that are forced into competition with these agricultural encroachers. The present-day problem is as simple *and as complicated* as that.

Probably it is realistic to suppose that the progressive and cumulative shrinkage of the nesting grounds is a tendency not likely to be reversed. It is likely, too, that other areas now contributing to the requirements of waterfowl will be withdrawn in favor of an agriculture geared to provide for a sky-rocketing human population. With this as a probable future outlook, it is even more imperative that we make fullest use of our present resources.

The resources are not altogether modest. In this country the combined federal-state expenditure in behalf of waterfowl amounts annually to about eight and one-half million dollars. Practically every State in the Union now supports waterfowl work of some sort. The programs include substantial activity in land acquisition, habitat improvement, and research.

Unfortunately this rapidly expanding waterfowl program has not always carried with it a liaison between individual states, and between all states and our federal agency, as close as would be desirable. As a matter of fact even *within* our relatively large and complex organization, where phases of waterfowl work occur in several administrative branches, we have not always coordinated our own activities to the most desirable degree.

During the past year the Fish and Wildlife Service has effected some realignments of responsibility and added personnel which we feel will contribute materially to satisfying some of these long-felt needs. In particular we expect recent changes to strengthen our cooperative ties with the states, to clarify responsibilities within our organization, and to augment generally our participation in "a broader waterfowl management program."

As most of you know, the Branch of Game Management of the Service in an earlier era was primarily a law enforcement activity. During recent years this Branch has been assuming greater responsibilities for other phases of management. Currently, a substantial program of depredations work is handled principally in this unit, and personnel of the Branch, also, have been contributing substantially to the fact-finding program of the Service. They are doing a good job and I should like to take a moment to tell you about it.

Fish and game departments are keenly aware of the need for strict game law enforcement. Yet many recognize that a payroll of 100 or more individuals competent only in enforcement is a luxury that few organizations can entertain. In the face of a strong public expression that law enforcement and technical responsibilities can't and shouldn't be mixed, a number of States have gone ahead, substituted conservation officers or a like equivalent for game wardens, and added to the sphere of responsibility. They found that it worked.

Since 1934 when Ding Darling closed out a Biological Survey Section of Law Enforcement in favor of a Branch of Game Management, we have gone even further. While adding to individual responsibilities, technical and enforcement programs have been mixed organizationally. We are finding that it not only works but is logical and economical.

Admittedly we have a few old hands, who were employed as enforcement officers, and who have continued as good enforcement officers, but who have found it difficult to broaden their interests to keep pace with changing times. What outfit doesn't have them? At the same time we have a great preponderance of field personnel, new and old, who through individual initiative and on-the-job training have developed abilities to handle the variety of game-management responsibilities required in the modern-day position. Individuals whose primary training and interest have been in the field of enforcement are making substantial contributions to the technical and extension programs of the Service. Conversely, a number of our longest-haired biologists who have been vested with enforcement authority have handled enforcement jobs with a skill that has drawn plaudits from our most competent enforcement specialists.

Our present recruitment procedures for game management agents are highly selective. We intend to make them more so. Currently a candidate for these jobs must have four years of general and specialized experience to qualify. Furthermore, the Civil Service competitive examination for the position requires of an applicant an intelligence and aptitude quotient equivalent to that of a college man. Hundreds take this exam—very few pass it.

Among those appointed in recent years, several are graduates of law school and a number hold degrees in wildlife management. In one of our regions we recently appointed five new agents, all of them college graduates in game management. Before coming into the Service each of them had demonstrated fully his abilities in enforcement work. Men of such experience and training have every qualification for broad participation in a waterfowl management program. They can do so without the slightest distraction from a basic enforcement responsibility. We expect that they shall.

Last year Congressional approval was given to use an additional 5 per cent of duck stamp revenues for enforcement purposes. These additional funds made it possible to enlarge the game management field force by about 20 per cent. We have added to our field staff 166 new game agents, one pilot-agent, and two experienced undercover operators—one on each Coast. A portion of the funds, also, was allotted to meet the long-felt need in the Regional Offices for an assistant supervisor of game management whose principal responsibility will be to deal with enforcement phases of the program.

Concurrently with this increased staffing of the Game Management Branch, several other changes were made. A Section of Waterfowl Investigations, which has a primary function of developing inventory procedures and determining the annual status of waterfowl, was transferred to this Branch. The effect was to place under one administrative unit most of the Service's activities concerned with waterfowl surveys and inventories. We expect as one result that there will be better coordination of activities and most efficient utilization of manpower and facilities.

Technical supervision for this enlarged Branch has been further augmented through the assignment of a second assistant supervisor to the Regional Office staff. This additional staffing will permit one assistant to give primary attention to matters of law enforcement, depredations work, etc., and the second to give emphasis to technical responsibilities in the program. In particular there is abundant opportunity to effect a closer coordination of certain programs and objectives of our Regional Office units engaged in waterfowl work. And the game management staff at this level will be expected to satisfy the present need for a better assimilation and interpretation of data already being obtained by our Branches of Refuges, River Basins, Research, and others engaged in waterfowl work.

We feel, too, that the technical man power recently added to the Regional Offices will strengthen greatly our liaison with the states. By maintaining contact with state personnel and programs these men should rapidly come into the position of being able to recommend standardization of method and coordination of work that will add much to our joint effort in building "a broader waterfowl management program."

At this point I might add parenthetically that modifications in the Washington office organization of Game Management also have been made. Our departmental staffing pattern parallels that which I have described for the field. In addition to the chief of the Branch we have two assistant chiefs, one having a primary responsibility for law enforcement and the other having initial responsibility for the direction of technical phases of the program. Also, administrative details of the over-all branch activities are organized in a section of law enforcement and a technical section to deal with investigators and other management aspects of the work.

All of you are undoubtedly familiar with the flyway organizations which have come into being in the past year or two. While a few group-state Committees having similar objectives have been functioning for several years, it has been only recently that all member states in each flyway have established a formal organization to work with waterfowl problems. It seems to me that these committees are a substantial indication of state interest and willingness to back national waterfowl programs. Likewise they present an unparalleled opportunity for strengthening cooperative federal-state ties. We are anxious to work with these committees in all possible ways.

At this point in the development of the flyway organizations it is difficult to suggest a long-term functioning process by which we can best achieve our common goal. The committees have an obvious and immediate value, of course, in establishing a means of communication among our technical forces. Certainly, periodic meetings for this purpose should be encouraged.

At the same time there are substantial problems dealing with the accelerated loss of waterfowl habitat, conflicts of waterfowl with agricultural interests, and other basic items that will be logical considerations of these organizations. From some experience in working with the Black Duck Committee in the Northeast, and more recently with its successor group, the Atlantic Waterfowl Committee, it would appear that a working outline for a flyway program might be an early consideration. In the Atlantic Flyway this document has taken the form of "A Statement of Objectives." Even though this outline is in its fourth or fifth revision, it is still considered a highly dynamic statement, subject to frequent change and revision as circumstances and reconsideration warrant. Yet it has considerable value in that it has focused attention on basic issues and represents a measure of mutual agreement among numerous agencies and interests.

In order to facilitate our working with the flyway organizations we have established a new position in each of the four flyways. We expect these men to work closely with Regional Office staffs and the flyway groups in shaping up long-term management objectives, and in serving as a clearing center for information developed over the entire flyway. The new position will serve a valuable function, too, in bringing a flyway perspective to many of our operations which, of necessity, are conducted on a regional basis.

In pointing up recent changes in our federal organization, particular mention has been made of advantages from the standpoint of strengthening and extending a program of mutual participation. Emphasis on this point is not intended to carry the implication that federal-state cooperation is not already very substantial. It is. Last year, for instance, 26 states contributed to the annual production inventory by conducting breeding-ground surveys. The total participation included the efforts of about 200 individuals who worked on ground counts, plus 43 aerial crew members who worked from 18 planes. This, of course, was in addition to major contributions to inventory work made by the Canadian Wildlife Service, the Provinces and Ducks Unlimited biologists in Canada. In other investigative work the degree of state participation has been equally gratifying. Operations to estimate the hunter take of birds, measure wintering populations, and provide other information on waterfowl have received splendid support from state workers. Programs of land acquisition and habitat improvement for waterfowl have enlarged conspicuously in recent years.

In extolling this high degree of state participation and excellent cooperation, it should not be concluded that all of our activity has necessarily represented progress. One of the principal needs, it seems, is for a better coordination of our efforts and, to the extent possible, a better standardization of our methods. Much research now going forth on a purely local basis will reach full fruition only after it is integrated into a broader pattern covering other points in the flyway and the continent. The administrative means for accomplishing this type of coordination should now be present in the flyway organizations.

In connection with routine inventories and studies to provide management information for waterfowl, we have attempted constantly to evaluate and modify our fact-finding techniques. And while we are satisfied that present methods are superior to those of any time past, we are certainly not averse to abandoning any part of these in favor of something superior in the way of economy or accuracy of results. In this connection it seems reasonable to assume that the combined efforts of the technical committees should be effective in improving upon our methodology.

Many of our combined facilities and much of our effort is now being applied to provide information useful in establishing harvest regulations. With occasional exceptions the reliability and over-all value of such data will be increased through the use of statistical planning and analysis. We have already begun a reappraisal of many of our own operations in this light.

Much effort has been given to redesigning some of our breeding-ground inventory work to obtain results more susceptible to statistical analysis. Our coverage of productive waterfowl areas has reached a substantial point and the volume of data resulting is massive. We are hopeful that a measure of statistical design in getting the information will permit the returns to be used in even greater detail.

Furthermore, this year we are giving trial to a statistically designed method for measuring waterfowl kill and some of the mechanics of hunting. The experiment, which is being conducted cooperatively with the Post Office Department, had the benefit of the advice and guidance of statistical experts in the Bureaus of Census and Budget. Certainly, some means for reliably appraising the kill is essential to a proper undertanding of regulations, and we expect to give thorough trial to this and other methods of getting such information.

In the matter of regulations, we expect in the light of new information that a continuing reappraisal of regulatory needs will be routine. We expect as always to base these on the best possible information and to keep them as simple, understandable, and reasonable as the best interests of the birds and *all* the people will permit.

We expect to make mistakes. These will be remedied by discontinuing or amending the regulation and not by inference or instruction to our enforcement people that relaxation is in order. It is the job of enforcement to enforce the law fairly and impartially, vigorously and relentlessly, and without prejudging or interpreting the need for, or utility of, a regulation. Any conscious selection of regulations to be enforced and others to be ignored can have only the one result of stimulating a wholesale disregard of all regulations, state as well as federal.

To the extent that waterfowl are an annual crop, probably one of the more promising means for increasing hunter opportunity will lie in the closest possible cropping consistent with insuring adequate breeding numbers. This, of course, will require an even greater refinement in inventories of the type already mentioned and considerable investigative work in other directions. Some additional index to annual trends, particularly in the form of a refined post-hunting audit, would be a valuable safeguard against overutilization. A well-coordinated program of banding, both on the Canadian breeding grounds and in the States, would accomplish a great deal in permitting a more detailed consideration of regulatory measures. These and similar inquiries are of a sort that lend themselves to cooperative programs and as such would seem to be proper considerations for the technical flyway committees.

Of course, management of this type, while good conservation, is negative to the extent that it doesn't produce more ducks. As a long-term objective a waterfowl management program should give substantial attention to preserving and enlarging upon the year-round requirements of the birds.

To what extent these needs can be met is problematical. An explosive growth of human populations both nationally and world-wide is placing increased demands on agriculture. Each spring there are fewer nesting sites on the breeding grounds. And each fall and winter there is increased opposition to the birds from agricultural interests in the wintering grounds and all along the flyway. Even with today's nominal waterfowl populations, crop depredations have reached serious proportions in a few areas. Probably in the final analysis it is circumstances of this sort that will determine the ultimate fate of waterfowl. In any case they are problems which will call upon our utmost in ingenuity to solve and will require a united front not only from federal and state agencies but from all waterfowl interests. We are optimistic that developments of the sort summarized here today will establish a coordination and unity of effort effective in meeting the problem.

DISCUSSION

CHAIRMAN SCHNEIDER: Dr. Linduska's paper is now open for discussion.

Thank you very much, Dr. Linduska, for that excellent analysis of the program of the Federal Government in connection with the management of the waterfowl resources.

I would like to take this occasion to thank, on behalf of the Institute and both Mr. Malaher and myself, those who have presented this fine series of papers which have been presented, covering the waterfowl program throughout the North American continent.

The panel on waterfowl is now concluded.

PART II

TECHNICAL SESSIONS

TECHNICAL SESSIONS

Monday Afternoon — March 9

Chairman: E. L. CHEATUM
Chief, Bureau of Game, State Conservation Department, Albany, New York

Discussion Leader: A. M. FALLIS
Director, Department of Parasitology, Ontario Research Foundation, Toronto, Ontario, Canada

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DISEASE, NUTRITION, AND CONTROLS

OUR DISREGARDED RIGHTS-OF-WAY—TEN MILLION UNUSED WILDLIFE ACRES

FRANK E. EGLER
American Museum of Natural History, New York, New York[1]

INTRODUCTION

I appreciate the opportunity that this Conference has granted me to focus attention on an interesting and neglected subject. I know that many besides myself have considered it already, but I trust my treatment may add a few new thoughts. It is not my intent to "tell" in the sense of forcing facts; it is my hope to "sell"—sell an idea. The idea is not original by any means. It has arisen independently many times on the part of field workers who have had to look on telephone lines and power lines crossing large, otherwise undisturbed, forest areas. We may not like these rights-of-way piercing what remains of our wildernesses, but they are an essential element of our civilization that none will wish to eliminate.

My own role in this field has been little more than that of a switchboard operator, plugging in wires, and trying to get connections between diverse groups of people. There are chemists, chemical manu-

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facturers, spraying contractors, electric, 'phone, and other public utility corporations, highway departments, conservationists, wildlife managers, and plant ecologists. Of them all, strangely, those in the field of plant ecology have helped me the least. For right-of-way vegetation management, I have had to pick and choose most carefully from the ecologic literature, and temper the gleanings with some of my own research (Egler, 1947, 1948, 1949, 1950, 1951a, 1952b; Egler and Pound, 1952) that started in student days.

The picture that takes form is, to me, very surprising. I know of no other aspect of land management where a new approach promises not only to reduce costs for the primary land use, but to raise to a high level, and without one cent of additional costs, a totally unrelated, but nationally needed, secondary land use. After more than half a dozen years of field experience in half the states of the Union on this special work, I consider the situation ripe for preliminary generalization. The thesis of this article is that if the vegetation of rights-of-way of many parts of this country were managed for the lowest costs alone, on a long-term basis, botanically planned, they would *also* be supporting a near optimum of wildlife food and cover of naturally occurring plants.

The problem is not only one of biology and technology. There are certain important groups in the country who, either for personal profit or because they cannot train their sights on distant goals, are actually, and in a large way effectively, not only working against this potentiality, but permanently destroying the possibility for others. If this right-of-way acreage is to be added to the game habitat of the nation, it is going to take the active leadership of wildlife groups, in cooperation with utility organizations. Aside from the unavoidable displeasure of some that are involved, I am certain this cooperation can be actualized much more than it already has been.

I admit to slowness in bringing this matter to the attention of professional wildlife groups. My delay—probably an overdose of caution—was because I wished to be absolutely sure of the coordination of three relatively different fields of knowledge:

1. The kind of vegetation, in physical terms, which would best serve the material needs of the highway departments and the utility corporations, in regard to patrol, maintenance, and repairs.
2. The food and cover needs of various forms of wildlife.
3. The phytosociological behavior of this vegetation, especially in regard to its invasion by forest, and thus the future costs of its botanical upkeep and maintenance.

It is the first and third points that I would like to discuss in relative detail under the headings of: (1) problems in vegetation management, (2) cross-country rights-of-way, (3) roadsides. These sections will be followed by a consideration of chemical brush control, by standard techniques using formulations of 2,4-D and 2,4,5-T. The chemical may be applied selectively using knapsack sprayers, or applied overall, in blanket fashion, using power sprayers.

PROBLEMS IN VEGETATION MANAGEMENT

The only aspects of wildlife management that bear discussion in this paper are those of habitat management, the production of suitable food and cover plants. In turn, they prove to be problems within the scope of general vegetation management that have application not only to rights-of-way, but to all wildlife lands as well.

Conversion vs. Maintenance. Vegetation management on rights-of-way is already implied as involving two totally different procedures. The first, which for want of a better term I am calling Conversion, is of immediate concern and involves the root-killing of the existing unwanted woody plants. This is the same problem that all wildlife managers have when they try to create openings in the forest for additional edge effects. The second and future problem, which I am calling Maintenance, involves the periodic removal of whatever unwanted woody plants invade these areas. Conversion is primarily a chemical problem, and the cheapest and most effective technique at this time appears to be selective basal spraying. Maintenance, or rather the postponement or prevention of maintenance, is largely a botanical problem. It is this last that I want to discuss further, for it is essentially a problem in plant succession.

Maintenance and the succession of physiognomic types. Observational studies of plant succession, using those on abandoned agricultural land as examples, can be generalized in terms of a succession of physiognomic types. First on the bare soil are coarse rank weeks, such as ragweed or pigweed. These are followed by grasses. Then the vegetation is dominated by rank perennial broadleaved herbs. A shrubby stage follows; some years later a forest appears, usually of light-tolerant rapidly growing trees, and followed by a forest of shade-tolerant species. In one form or another this succession of physiognomic types generally occurs. The problem in right-of-way management and game management is to set back this development, deflect it, or otherwise stabilize it at one of the pre-forest stages. Any management of this land is directly dependent on the nature of the floristic "mechanics" that is responsible for, that "causes," this succession. Two distinct principles are involved. Even though both are present in any one type of vegetation, they are best separated for discussion.

The first is ''Relay Floristics''; the second, ''Initial Floristic Composition.''

Succession and Relay Floristics. The term relay floristics refers to the conventional textbook type of old-field succession, the one that I suspect most of you have been believing is responsible for much of the vegetation change you see around you. By this principle, one set of plants invades the land, and changes the site so much that they make it unfit for themselves, while opening the way for other plants of the next stage. This in turn alters the site eventually killing the plants, and allowing still another set of plants to enter. In this manner, the grass stage is destroyed by an incoming relay of heavy herbs, which in turn allows shrubs to enter. The shrubs act as nurse crops for the trees, which then destroy the shrub stage. If this is true, selective basal spraying, in my opinion, gave us for the first time in history a practicable tool for ''setting back'' this succession. For example, it could be set back from an incipient forest to any one of several shrub or grassland stages, depending on what kinds of plants were pinpointed out. The chemicals, organic compounds, distintegrate in the soil, and leach out within the year, leaving, as far as I can observe, no other effects on the community. If I may speak from the knowledge of reinvasion on my experimentally sprayed areas, of interpretation of adjacent old-fields with known dates of abandonment, and of recent observational work in many states, I can say that a relatively minor part of such vegetation development is due to relay floristics, such a minor part that in many instances it can be discountenanced.

Succession and Initial Floristic Composition. In most of the 40 acres that I now have under chemical management—typical northeastern abandoned farmland—I have gone over every square foot many times, looking not only for woody plants to spray but for seedlings of invading woody plants. Similarly, I have become seedling-conscious in all my recent field work. It is true that fire and grazing alter the picture exceedingly. But when considering areas that, following abandonment, are undisturbed by these or other factors, then it would appear that the succession of physiognomic types is due primarily, not to relay floristics, but to the initial floristic composition. In saying this, I say that it is due to the fortuitous distribution of seeds and living roots that were present at the time of abandonment. In the first few years the grasses were predominant, but coarse herbs, shrubs and trees were present, even though small or dormant. Later the heavy herbs increased in growth and crowded out the grasses. Still later the shrubs, originally there, took over. And finally the trees, there from the very start, dominated over the others and either eliminated them or much restricted their growth.

Type of Succession and Maintenance. I believe it will be readily understood from the above discussion that the problems of future maintenance are directly related to that type of succession which is predominant. If relay floristics is predominant, then the land manager has constantly to battle against continuously incoming waves of invading trees. If initial floristic composition is predominant, then he removes that arboreal component of the vegetation which came in far back in the past. Since he does not run the vegetation back to bare soil, he has no cause for concern about any reinvading trees.

The actual field problem is not quite as simple as that. All studies and observations are collectively pointing towards the generalization that each stage of vegetation development has its own special component of an invading relay that contributes to the next stage. For example—and perhaps contrary to what you might at first expect—the early stages the grasslands, are much more readily invaded by a few kinds of trees, especially pines. At Norfolk, both white pine and white ash can invade the grasslands in such quantities that they become maintenance problems. Ash in particular, can come in so very densely that the seedlings form a 100 per cent coverage at a height of 2 feet. Since ash is especially resistant to chemical sprays, I am not yet sure how I can handle this situation! In contrast to the grasslands, covers of various low or tall shrubs, certain heavy herbs, like a few of the goldenrods and some ferns, can form plant communities which are extremely resistant to invasion by tree seedlings. On a documented area in southern New York state, such a cover, of spray-sensitive species, has already existed for 17 years, without indication that it is yet being invaded by trees. The cheapest long-term management for low vegetation is therefore that type of conversion which will result in a community having the lowest incoming relay. and thus the lowest maintenance costs.

CROSS-COUNTRY RIGHTS-OF-WAY

Public utilities of various kinds make use of rights-of-way. Electric power corporations have both high-voltage transmission lines and low-voltage distribution lines. The former are on rights-of-way that may be 100 or more feet wide. Telephone service requires cable lines on narrow rights-of-way. There are pipelines for oil and natural gas. The requirements for all these vary in minor details, but that for the large transmission line may be used as a sample (Egler, 195b, 195c, 1951d, 1952a; Ibberson and Egler, 1951).

The wires are supported on towers that may be of steel or wood, and of various types of construction. Many lines are patrolled by foot, and for such purposes, a practicable walkable path, preferably of open grasses, is necessary, either at or close to the center of the right-of-way. Under the wires, and for short distances on each side, the vegetation should be kept low—under two feet—so that it will not inconvenience ingress in times of emergency and that there will be necessary space for repairs and maintenance. Outside of this central strip, there are four "mechanical" limitations to the vegetation: (1) No trees whose branches would grow into the wires should develop; (2) no trees that may fall into the wires in case of blowdown should grow; (3) no branches should grow in such a position that the sag of the wire, in high winds, will blow into them; and (4) there should be a clear demarcation between the forest off the right-of-way, and the vegetation on the right-of-way, so that there can be no property dispute in the event of removal of some trees on the right-of-way. With these as limitations, I think you can see what vegetation is "permissible" on a right-of-way.

It takes no ingenuity to realize that the vegetation which can fit into this pattern is practically an optimum combination of "edge effects" for many of the more important wildlife species. Plants already existing on the land are utilized to form a variety of parallel edges—a grassland trail at the very center, a broad band of low shrubs and ferns with intermixed grasses; then higher shrubs such as viburnums, cornels, and tall blueberries, azaleas and low junipers; and finally tall shrubs on the sides, such as willows, alders, amelanchiers and redbud. All these covers, except the grasses, are those which in general are most effective in keeping out tree seedlings, and thus, once attained, are the cheapest to maintain through the years.

ROADSIDES

Roadsides, by their very nature, are more variable and more difficult to generalize about than are the rights-of-way. Any one roadside consists of several parts, involving a shoulder adjacent to the pavement, a ditch, then generally a mowed strip, then an unmowed strip. It is this unmowed strip which is of concern to us now. Its actual location in relation to the pavement is variable, depending on speeds for which the highway is constructed, visibility factors in regard to curves and intersections, effect as snow fences, *et cetera.* The type of vegetation permissible is often related to the use of adjacent land, as to whether it is in crops or forest. For highway requirements, this unmowed strip can be that vegetation cheapest to maintain which does not grow out into the highway or up into local 'phone or power lines. Other factors are often brought in. There are a surprising number of people who see one rabbit run over on the pavement and immediately want to start a campaign to remove all "game habitat" from all roadsides. They completely overlook the fact that the habitat that produced the rabbit may also have produced two dozen others that did not get killed, as well as large numbers of small birds that know how to stay clear of the automobiles. They also forget that there are miles and miles of back roads where even that one rabbit also would have stayed alive. There are other people that will have record of a highway deer accident, and will immediately blame it on the roadside brush, forgetting that the deer is a wide-ranging animal. In addition, there are growing masses of data on insect and rodent populations of brushy and grassy field borders, which point in general toward the brushy borders as being the more desired. In full realization of many exceptional instances, I think I can say that mechanical requirements of the highway departments for the unmowed strips are satisfied by shrub covers of plants that are already there. These are cheapest to maintain for long-term periods, they are most attractive for landscape purposes, and they add to the acreage of game-producing habitat.

I have postponed until this time any mention of the acreages involved in rights-of-way and roadsides. Unfortunately there have been no good estimates made. Utility corporations generally do not have data on the amount of their lines in brush. The Pennsylvania Electric Association has reported on eight of its companies having sprayed some 25,000 acres of bush. Thus each company would have sprayed an average of over 3,000 acres, implying that each has considerably more than that in right-of-way brushland. Highway mileages are better known, yet roadside acreages are but seldom computed. Ohio is said to have 330,000 acres of roadsides, an area equal to the largest county in the state, and exceeding the total area of all publicly owned forests. Iowa, for its secondary roads alone, has a roadside acreage totaling 427 acres, larger than the average Iowa county. By rough estimate, I would say that there is more than 10 million acres east of the Mississippi River in rights-of-way and roadsides. Fundamentally, this is not game-producing land and cannot be primarily so managed. Nevertheless, if the unwanted trees are selectively removed by spot spraying and the natural mixed brushy cover is allowed to develop, we find we have not only attained the cheapest type of vegetation management for the highway departments but at the same time we have obtained a fine game-producing habitat—and without any additional expense by wildlife groups themselves.

SELECTIVE SPRAYING VS. BLANKET SPRAYING—SHRUBLAND VS. GRASSLAND

I am, at this point, guilty of grossly misrepresenting the favorableness of the situation as it exists on the rights-of-way and roadsides of the nation. In actual commercial practice we are confronted by two opposed and totally different proceduces of brush control, of which that above described, favorable to wildlife, is exceedingly in the minority, though not for reasons difficult to understand. These two systems differ in the way the chemical is applied; they differ in the botanical results after spraying is effective; they differ in the quantities of tree seedlings that reinvade; and they differ in values as game habitat.

Selective spraying involves the use of knapsack sprayers with high concentrations of the chemical in oil. Workers must know their plants in the dormant season, and, because of regional differences in vegetation, each area must be specially planned botanically. Although on first thought, one might assume that this system would be prohibitively expensive in terms of high-quality labor and an enormous number of man-hours, three years of commercial experience have shown it to be on a competitive basis with the blanket-spraying discussed below. The seeming paradox is due to the fact that there are not as many trees among all the shrubs as one might think at first glance. Furthermore, more and more workers are finding that basal spraying, though slower in effect, is a more efficient root-killer; and fewer plants have to be resprayed. As to botanical results, selective spraying is designed to fit within the limitations previously described in regard to accessibility for maintenance, and ingrowing and infalling trees. The terminal result involves what may, with some liberty, be called "shrubland," but which includes whatever patches and intermixtures of grasses and coarse herbs are already there. An open grassy trail is near the center; low shrubs are under the wires; from there to the margins, all other plants can be left in which do not become forest trees. The end result, a valley effect, is a constantly varying mass of cover types that provides practically an optimum amount of edge for the area. These covers, with a few known exceptions, do not act as nurse crops for forest trees. They act as retardants to reforestation and consequently cut future maintenance costs to a minimum. It is the policy of the Museum's Committee for Chemical Brush Control Recommendations for Rights-of-way to strive for a cover which can go 25 years without reinvasion.

Blanket spraying is the system most extensively used for brush control, and the one favored by manufacturers and most contractors. The reasons for the ease of selling this idea are not hard to understand. Spraying is done in summer, with large power equipment, large quantities of solution, and relatively untrained labor. Color effects in the browning foliage are striking. The client figures he is getting something for his money. As for the botanical results, it is a flat side-to-side grassland, also very easy to sell to the utility corporations, for it is as photogenic as something out of Hollywood. In contrast, a view of a shrubland, in photograph or in the flesh, is just "brush" to some electrical engineers, who believe it will grow up to forest the way they know brush has always grown. As to the problems of future tree reinvasion, the manufacturer and most contractors, apparently not having personnel interested in this subject and it not being to their future advantage to be interested or for some other unknown reason, have maintained a stubborn silence on the issue. One of the most extensive such blanket-spray jobs is close to Washington here. Scrub pine is invading so rapidly that the company plans to respray once every five years. The low shrubs, incidentally killed in this spray, are berry-bearing ericads which are known to retard invasion by this pine. As to game habitat, I have to rely on the wildlife literature. This grassland is not, however, a "natural" grassland. If the spraying had been effective, all spray-sensitive herbs would have been killed out, including goldenrods, lespedezas, polygonums, clovers, vetches, and others. There are times that the remaining grasses are of such seed-producing species as to be valuable for animals, but to my knowledge this is the exception rather than the rule. As for edges, there are only two narrow ones, one on each side composed of the overhanging limbs of trees. This is your wildlife alternative, alternative to the concentrated mass of different kinds of edges that comes into existence with the valley effect. We will grant that there are some true grassland species of animals, which would be favored by having large areas of pure grass. On the other hand, I believe that even some of these prairie animals would not find their "minimum area" requirements satisfied by the long narrow strips of a right-of-way.

There are various workers in this field of chemical brush control who think they have adopted the botanical philosophy of selective-spraying when they send in knapsack crews *after* one or more blanket-sprayings. I cannot speak too strongly against the incaution of such assumptions. Such men generally think in terms of, and see, only the trees. It is a matter of empirical fact that between the majority of trees and shrubs, the trees are more resistant to foliage sprays than the shrubs. Thus, by the time the trees are finally killed, the shrubs and desirable coarse herbs are practically annihilated. Their next argument is that the shrubs will reinvade the grassland and can be left in while reinvading trees can be spotted out. This is a beautiful thought, and I only wish it were true. On the basis of my own research, and of all observations, it appears that practically all the shrubs are part of the initial floristic composition, whereas trees are the prevailing incoming relay. These invading trees may come in so abundantly that practically a blanket spray is needed to take them out, and such spraying will remove what few shrubs may have either survived or re-entered. In short, the idea of first blanket-spraying and then selective-spraying is in most cases comparable botanically and zoologically to blanket-spraying alone, and it does not participate in the future low-cost features of the selective spraying.

CONCLUSION

In this discussion of the botanical problems involved with various types of spraying with 2,4-D and 2,4,5-T, I have tried to indicate the techniques involved, the botanical results, the relationships to wildlife food and cover, and relative future costs due to reinvading tree seedlings.

A comparison of the two systems, selective basal spraying and blanket foliage spraying, would appear to point wholly in the direction of the desirability of the former. Selective basal spraying is just as cheap in the first conversion stages, it fills the land with edge effects, and it is cheaper to maintain. On behalf of the wildlife potentialities alone, 10 million acres of it, it is my thought that the wildlife profession has something in which to be interested. It will not cost wildlife agencies any monetary or material outlay to have this land so treated as to give optimum wildlife cover. But it will require a definite attempt to counteract the influence of many chemical manufacturers and most (but not all) contractors who, without any thought for the future of the land, but sometimes with a definite thought for their own future, have extensively advertised the advantages of the only kind of spraying they know how to do. On the other hand, this land management is really the problem of the utilities, who are not only seeking lower costs for themselves but recognize the value of satisfactory public relations. As a parting thought today, I suggest that if you are interested in the development of right-of-way land for improved wildlife habitat, you directly contact officials of the utility corporations. My own relationships with them have been almost always extremely gratifying and pleasant, and I am certain you will find them friendly, open-minded, and ready to cooperate on matters of general interest to the public.

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DISCUSSION

CHAIRMAN CHEATUM: Thank you, Dr. Egler.

DR. FALLIS: Before opening for discussion, I should like to explain something to the audience. At first when I saw the program I felt very embarrassed at my ignorance on many of the topics for this afternoon. However, this was restored when I saw that Dr. Cheatum was going to be beside me, and you are all familiar with his wisdom and wide experience, so, as I say, my confidence was restored.

Dr. Egler has opened up a new field for you. I think we should have discussion from two or three groups, at least, who are interested in the wildlife aspect of the rights-of-way; the utility companies and industry we know are interested.

It seems to me that the ever-increasing pressure of the human population on the wildlife habitat probably makes it increasingly necessary to use all available space. Perhaps this is one avenue that has opened up that we should be giving a lot of thought to.

MR. BABBICK (North Carolina): I would like to ask Dr. Egler to explain just a little bit more the differences in the techniques of producing the upper diagram as compared to the lower diagram.

DR. EGLER: The upper diagram requires selective approach. In short, you generally have on a right-of-way a mixture of shrubs and trees. It is only the trees that need to be taken care of.

In my opinion, 5 gallons with a good concentrated mixture of these chemicals, 214 and 215 in water, generally will do the trick. The man-hours are cheaper, the amount of chemical is less, and the amount of the actual spray is less than what you might think at first.

The lower diagram is done with heavy power equipment using many more gallons per acre. The power chemical contractors and manufacturers have been up against a problem there in that the upper diagram requires some knowledge of plants. The contractors in general have not had the personnel to do it. They have fought it decidedly because it means training the personnel, and that is always a problem. The second one is more photogenic. It is easy to sell, so blanketing the line is continued.

I might say that I have here in Washington a 23-minute colored sound film showing how these things are actually done in the field. If there are even half a dozen people interested, I would be glad to show it, but I realize that the schedule is filled.

DR. FALLIS: We have time for just one more question. I presume, Dr. Egler, that the habitat requirements may differ in different states and that some people may be more interested in one type of wildlife than another. Does that mean that we have to have different types of spraying?

DR. EGLER: Not so much. A different chemical is used, or the technique may be different, but it is true that every region must have its own botanical procedure laid out. That is not too difficult. Any local wildlife man knows what he wants in that region. One thing that has militated against the use of the upper diagram is that the personnel have not always been available. You might say that this one forestry plan for heavy vegetation regions is not suitable everywhere. It has to be modified to fit the requirements of the region in which it is to be used so that it becomes more clearly feasible to do this at a suitable cost.

DR. CHEATUM: Dr. Egler, I want to thank you for a very stimulating paper, and I hope that the wildlife managers here who are charged with the responsbility of developing food cover programs can take back home with them this very practical suggestion for the plan of action, at least give it very serious consideration.

The next speaker is Roger Latham, who is with the Pennsylvania Game Commission. Dr. Latham is dealing with a subject that has long been controversial; that is the rightness or wrongness of bounty systems. He will analyze as objectively as he can the present status of the Pennsylvania bounty system and give recommendations for its improvement. Dr. Latham.

AN ANALYSIS OF THE PENNSYLVANIA BOUNTY SYSTEM

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INTRODUCTION

Pennsylvania's bounty system, one of the oldest in the country, has been the object of conflicting opinions for many years. On the one hand, it is held up as an exemplary system—one in which payment is centralized in a single office manned by experts and one in which fraud has been reduced to a minimum. On the other hand, it has been criticized relentlessly by a group of wildlife biologists who feel that *any* bounty system is impractical in modern game management.

The purpose of this report is not to discuss the merits or demerits of bounty systems in general. but rather to point out the possible inefficiencies in the Pennsylvania system and to make suggestions for its improvement, particularly from the standpoint of reducing costs. It is believed that this cost can be reduced without impairing the effectiveness of the system in the control of specific predatory animals believed to be detrimental to game populations.

METHODS OF ANALYSIS

The problem of analyzing the Pennsylvania bounty system was approached in three ways. The first approach was a detailed study of the bounty records as kept since 1913 by the Bounty Claims Section in Harrisburg. The second was by oral interviews with 1,289 claimants, representing a random sampling for the state for the two-year period prior to the inception of the study. The oral interview method for obtaining data was used for one major purpose—to determine what per cent of the total number of predators submitted for the bounty payment were killed primarily for this reward. More or less incidental to this primary purpose, other data were secured: (a) the manner in which the animals were taken—shot, trapped, or otherwise; (b) whether the animals were killed while the claimant was hunting game; (c) whether the animals were killed to protect poultry or other livestock; (d) if the animals were taken in traps, whether the traps were set deliberately for the predators taken, or whether they were set for other furbearers, house rats, etc.; and (e) if dogs were used to hunt foxes, whether hounds or creepers (hole dogs), or both, were used. Naturally, considerable information was volunteered by the persons interviewed concerning the abundance or scarcities of the various predators, population trends, the destructiveness to game and poultry, and other similar items, plus their varied opinions, sentiments, and reactions to the Game Commission and the bounty system.

The third method of analyzing the bounty system was by the use of 524 questionnaires as an accuracy check for the oral interview method of securing data.

FINDINGS

Foxes. The red and gray foxes will be discussed jointly since there appear to be few, if any, differences in the problems of management and control presented by either species. The fox bounty records for a two-year period were examined and tabulated to show the number of claimants who had submitted only one fox, two foxes, three, four, five, six to ten and 11 or more for bounty during the fiscal year. Of 10,183 claimants submitting foxes for bounty during the 1948-49 fiscal year, 5,823 (57 per cent) of this number killed only one fox during the entire year.

Desired information was obtained for 712 claimants from the 1948-49 fox bounty list by the oral interview method, while 250 claimants from this list completed and returned questionnaires. The 712 claimants had bountied a total of 3,867 foxes for the year, and the 250 claimants answering the questionnaire had taken 1,579 foxes.

All findings from the oral interviews were tabulated under four numerical headings in accordance with the number of foxes bountied by each claimant: one fox, two foxes, three to five foxes, and six or more foxes. The poll was designed to determine how many foxes within each group were taken (1) primarily for bounty, (2) incidentally to other activities, (3) accidentally, (4) as protection to poultry or other livestock, or (5) as protection to game. Only 27.1 per cent of the foxes falling within the single-claim group were killed for the bounty. As would be expected, a far greater proportion (67.5 per cent) of the foxes in the two-fox claim category were taken for the bounty since few persons would have the opportunity to shoot more than one while hunting game, or to kill more than one on the highway. Most of the three-to-five fox claims represented the efforts of part-time trappers and hunters using hounds or creepers (76.3 per cent). Within this group, there was a considerable number (16.8 per cent) killed to protect poultry. Sometimes these were trapped within close proximity of the barnyard or chicken range, but often this number were taken as pups from a nearby den after the parent foxes had stolen chickens or other poultry as food for their young. Almost all (93.4 per cent) of the claims of six or more foxes were submitted by trappers or hunters who had put more than casual effort into the taking of the foxes. Again, a number were killed to protect poultry, and litters of six to eight more pups from a single den were included in this group.

Along with the information concerning the reasons for killing foxes just described, a record was also kept of the methods used by each claimant for taking foxes.

The past history of the fox bounty in Pennsylvania is one of outstanding mismanagement. Numerous writers have used these fox bounty records to *prove* that bounties cannot control predatory animals. But, in the case of the fox, the bounty system was never given a fair trial as a means of control in Pennsylvania. It is evident that a bounty cannot succeed as a control measure unless the reward is increased in direct proportion to the added difficulty of taking members of an ever-diminishing population, or unless the bounty payment is high enough in the first place to insure final control.

An examination of past bounty records shows that a continuous $4 bounty on foxes in Pennsylvania has not induced the degree of control desirable for intensive game management. When the fox population is very high, as in the 1944-46 period, the $4 payment appeared to be effective in reducing the annual take from about 50,000 to about 30,000 to 35,000 foxes. But then there was a leveling-off because at that density many trappers no longer found it profitable to trap. It then becomes a matter of ''fox management'' or ''fox farming'' by the professional trappers. These men are careful that they do not over-trap a particular region, and may even release all vixens late in the season so that the next year's supply is insured. Or, they may trap one portion of their territory fairly intensively one year, permit it to rest completely for one season while they trap another area, and then return to the first the following year or the second year. This can be done because only the professional trapper, who can devote full time to his enterprise, is willing to continue trapping under these conditions. Thus, the professional trapper holds the fox population at a "high-production" level and will not voluntarily reduce their numbers to the point desired by the Game Commission unless forced to it by competition. At this point of low return, the part-time trapper and amateur lack the necessary financial stimulus and offer little competition.

But if the bounty payment is raised when this leveling-off occurs, immediately the hunting and trapping pressure is returned to the previous high intensity and it is impossible for the professional trapper to "manage" his foxes as before. Now if he "rests" a portion of his trapping territory, someone else will trap it anyway, and he is less likely to release vixens for breeding stock because he knows that the next person who catches them will probably collect the bounty. It is obvious then, that if a certain population level needs to be reached and maintained for the best interests of game, the bounty payments must be increased at each interval of stagnation. The Pennsylvania fox and weasel bounty history indicates an almost complete reverse tendency. Instead of raising the fee at the intervals when foxes and weasels were exhibiting marked reduction, the inclination has always been to decrease the payment or to remove it altogether. The bounty then would be restored only when the predator once again became intolerably abundant, thus losing all that had been gained. Little wonder that adequate control was never realized nor maintained!

The immediate reaction to a suggestion for a sliding-scale of bounty payments is that a Conservation Commission financed by hunting license fees cannot afford to pay a reward for, let us say, $10 for each fox killed. But, are not 50,000 foxes at $4 more expensive than 10,000 or 15,000 at $10 each? And more important, when 30,000 to 50,000 foxes are being killed at $4, the purposes of the bounty (reduction and control) are not being achieved. If a gradual increase to a $10 payment per fox insures a reduction to a point where only 10,000 to 15,000 are taken each year, then the money expended is a far more practical investment in terms of rabies control and possible benefit to game.

During the past two years, over 15,000 of the 67,792 foxes bountied were killed for reasons other than for the bounty reward. Of the 12,000 foxes submitted as single claims during these two years, only 27.1 per cent were killed for bounty. For economy's sake, it seems desirable to eliminate these single claims. By this action, $48,000 could have been saved during the two-year period.

To do the obvious thing—refuse to pay bounty on claims of less than two foxes—would certainly invite fraud, because there would be a definite pooling of pelts in every neighborhood. A more workable solution, perhaps, lies in the issuance of a fox *bounty license.* This system would require each man who anticipates hunting or trapping for bounty to purchase a license. If this license were to cost $4 (the bounty payment for 1 fox) it should eliminate almost all single claims and many other small claims of incidental nature. Through this method, if fraud can be held to a minimum, about one-fourth the annual cost of the fox bounty could be saved without appreciably reducing the total kill of foxes. This $24,000 a year saved (based on the records of the past two years) plus the money received from bounty licenses should aid considerably in reducing the cost of fox control. This bounty license would not restrict the efforts of young boys and part-time trappers as a regular trapping license would, and is, therefore, more desirable in many ways. Youngsters should be encouraged in every way to trap and otherwise participate in healthful outdoor recreation, and no restricting influence, such as a trapping license, should be placed on their activities.

The taking of foxes by hunting with hounds or creepers should be given greater publicity in an effort to influence more people to adopt this excellent sport. Any decided increase in this activity *should* have three positive benefits: (a) a reduction of foxes with a consequent benefit to game and to poultry raisers; (b) an increased amount of outdoor recreation for those adopting the sport; and (c) the diversion of a certain amount of hunting pressure from game to foxes. Those who actively participate in this sport will find that their "hunting season" now extends from September through March. This may aid in eliminating some of the criticism directed toward the shortness of the small-game season, the decreased bag limits, and other similar objections. Also, most sportsmen who hunt foxes feel that they are "doing their bit" toward the protection of game, and become more interested in its conservation and management as a consequence. Many fox hunters open the stomachs of the foxes they kill and examine the contents. When game is found, they feel doubly rewarded, because to them it means that another "killer" has been destroyed.

One man in Columbia County, with the aid of his companions, killed 110 gray foxes and several red foxes over his three hounds last year (1949-50). If this could be repeated all over the state, much good would be accomplished!

Weasels. Two very significant facts stand out above all others when past weasel management is analyzed. ***First, there have been no positive studies in Pennsylvania, nor any other nearby state, to show that the*** *weasel is sufficiently destructive to game to warrant control measures other than that gained through the annual fur harvest.* No comprehensive food habits study of the weasel has been undertaken by the Pennsylvania Game Commission, and no studies concerning its relationship to small game have been made on specific land areas. The five most complete food habits studies of the weasel in eastern United States, including one for Pennsylvania, show that 70, 83, 76, 88, and 93 per cent of the diet is composed of mice and a few other small animals such as shrews, moles, chipmunks, house rats, etc. Only 13, 17, 14, 8, and 0 per cent of the food was cottontail rabbit. Game birds occurred in negligible numbers.

It is perhaps unfortunate that nearly one and one-half million dollars have been paid in bounties on an animal whose exact ecological relationship to small game is unknown. Its reputed destructiveness to game has arisen almost entirely from unscientific observations. and no conclusive evidence exists which would prove that the weasel is any more deleterious to game supplies than raccoons, skunks, opossums, minks, stray house cats, crows, Cooper's hawks, and other predatory species upon which no bounty is paid. Hundreds of areas within the state support high populations of both weasels and small game, while other regions where weasels are scarce often provide poor rabbit and bird shooting.

Secondly, the weasel is a valuable furbearer and is trapped more for its pelt, at present, than for the bounty. The vast majority of weasels are taken, not by persons specializing in weasel trapping as in the case of the fox, but rather by fur trappers who set for weasels, skunks, opossums, muskrats, and other common fur animals and accept whatever enters the trap. This is clearly shown by the fact that only 240 (3.6 per cent) of the 6,690 claimants presenting weasels for bounty during the 1949-50 fiscal year caught more than 10 weasels during the year. In fact, 3,058 of the 6,690 claimants presented only one weasel, and almost all of these would have been killed even though no bounty were paid on this predator. A large majority of these single claims represented weasels caught in traps set around the barn, chicken house, or even in the cellar drain for house rats. Many others were killed upon the highways, clubbed by farmers in poultry houses or in the hayfields, or shot by hunters. Claims of as high as six or eight often represented the work of house cats which would catch them and deposit their carcasses upon the back porch, or of a spry farm dog which would destroy an entire family of young weasels as a board pile was torn down by farm boys. Entire litters are plowed out and sent to Harrisburg. But the greatest number of small claims (ten weasels or less) were composed of animals taken either incidentally to specialized trapping (caught in fox, mink, or raccoon sets) or taken on the common skunk-opossum-weasel trapline. Thus, the large majority of weasels presented for bounty would be taken in spite of the bounty payment.

As a result of the analysis of the bounty records and the personal interview poll, *it was recommended that the bounty be removed entirely from weasels for the following reasons*: (a) No positive proof exists that weasels are sufficiently destructive to small game to limit the numbers remaining for recreation during the fall hunting seasons; (b) there is no reason to believe that weasels are more detrimental to game population than several other predators upon which no bounty is paid; (c) the weasel population fluctuates greatly in spite of a constant bounty payment, thus suggesting a natural control; (d) the high fur value of weasels makes it an attractive prize for fur trappers and assures a constant annual harvest; and (e) the results of this survey indicate that at least 75 per cent of the weasels killed would be taken whether a bounty is paid or not.

Horned Owls. From the questionnaires and field interviews it was learned that only 40 per cent of the total number of owls sent in for bounty are taken by persons hunting or trapping primarily for this reward. In other words, 60 per cent of all the owls killed would have been killed whether a bounty was in force or not. Also, it was found that 44 per cent of the annual kill was taken during the three fall months and, since almost all of these owls were killed by hunters while hunting small or large game, this expenditure represents an undesirable inefficiency. *Therefore, it has been recommended that the bounty be removed during the months of November and December of each year.* This action would have saved about $10,000 during the past three years without noticeably affecting the total annual kill.

Sixty per cent of all owls submitted for bounty represented single claims for the year—that is, one owl per man per year. The feasibility of eliminating single claims by the use of a bounty license has been discussed under *foxes.* It is possible that this plan could also be applied to horned owls with a considerable saving. However, the elimination of bounty payments on owls during October, November, and December would automatically dispose of a large proportion of the single claims.

It was further recommended that consideration be given the problem of pole traps set for horned owls. In certain counties, the use of pole traps for owls has become widespread, and some men leave several of these traps set the year around. Nearly all large owl claims (ten or more) were composed of birds taken in pole traps. Probably most of these pole sets average from two to five protected hawks for each owl taken, and during the spring and fall migrations single traps may catch two, three, or more each week. Perhaps, for the months of April, May, September, and October, the use of pole traps should be outlawed.

As in the case of the fox, the sport of hunting owls by driving and by calling should be publicized. Here again, this "off-season" hunting would provide additional recreation for the sportsmen and, at the same time, decrease the numbers of resident owls. A number of men who completed and returned the owl questionnaires asked for information concerning the hunting of owls.

Goshawks. The goshawk, because of its emigratory nature, does not present the same control problems as the horned owl. Pennsylvania represents the extreme southern edge of this hawk's breeding range, and only an insignificant number nest in the more northern counties. During most years, it is probable that less than 200 winter in the state.

An analysis of the bounty records revealed that the number of goshawks presented for bounty during the past ten years (1940-1950) has averaged only 44 hawks per year. The greatest number of claims for any single year came at the peak of the abnormally heavy migration of 1936-37 when 1,080 were killed. Two years later only 52 were taken in the state. Of 61 claimants presenting goshawks for bounty during the two-year period (1948-1950) only three had killed more than one hawk, and each of these had killed only two.

The analysis also showed that a majority (58 per cent) of goshawks are killed by hunters during the October-November-December hunting seasons. A breakdown of the 1936-37 records revealed that 783 (73 per cent) of the 1,080 hawks were killed during October, November, and December. This is perhaps the most undesirable feature of a bounty upon goshawks. Since only a minute fraction of the hunters are capable of identifying a goshawk at a distance, and probably less than five per cent could positively identify one in the hand, the temptation is constantly before the hunters to shoot every hawk they can with the hope that it might be a goshawk worth $5. Since an average of only 44 goshawks a year were killed, it is obvious that great numbers of beneficial hawks were sacrificed each year for practically nothing. Every District Game Protector, and Justice of the Peace, has experienced the repeated visits of hunters with hawks which they believed (or hoped) were goshawks but which almost invariably turned out to be redtails, marsh hawks, or some other protected species. The Bounty Claims Section at Harrisburg has received every kind of hawk native to the state—all sent in as "gosawks."

In order to determine whether the bounty payment ($5) upon the goshawk materially affects the annual kill, a questionnaire was sent to *all* claimants who had submitted goshawks for the bounty during the 1948-49 and 1949-50 fiscal years.

The information gained from the goshawk questionnaires proved that the Game Commission at its January, 1951, meeting was wise in removing the goshawk from the bounty list. The findings from the questionnaires sent to all goshawk claimants for the past two years (1948-49 and 1949-50) showed that not more than 4.2 per cent of these birds are taken for the bounty and that all of the remainder would be killed without this reward. Actually, those included within this 4.2 per cent are of dubious classification, since none of these claimants took more than one hawk during the two years. *As a safe generality, it can be stated that the bounty has no effect upon the annual kill of goshawks and that, therefore, this expenditure has been a gross inefficiency of the system.*

Other Predators. There is good reason to believe that certain predators which are not on the bounty list at present may be more destructive to game than certain ones upon which a bounty is being paid. There is a constant pressure from hunters, farmers, and other groups for an extension of these fees to include raccoons, skunks, opossums, certain hawks, crows, and a great variety of other predaceous birds and mammals. However, *it is not recommended that any additional animals be placed upon the bounty list* unless, at some future time, carefully executed ecological studies prove a certain predatory species to be inimical to the best interests of wildlife conservation in the state and the bounty system appears to be the only workable means of reduction and control of that species.

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DISCUSSION

DR. FALLIS: Regardless of the merits or demerits of the bounty system, we must admit that Dr. Latham has made use of this system to collect biological data and try to explain something about our animal population which we didn't know before. Are there some questions for Dr. Latham?

MR. BARRON (Washington, D. C.): I have several questions I should like to ask of Dr. Latham.

One, what does the bounty study of the fox in Pennsylvania show as to the damage they do; two, does Pennsylvania encourage or discourage the hunting of fox with packs of hounds; and three, does Pennsylvania consider the fox as a legitimate game animal or strictly as vermin?

DR. LATHAM: We do encourage the hunting of foxes with packs of hounds. We have, however, two kinds of fox hunters in the state. We have the wealthy group riding to the hounds—red coats, and so forth—who, of course, like to protect the fox at all costs. We have the kill-fox hunters who are out primarily to kill the fox, and we are attempting to encourage both groups, as far as that goes.

In other words, it is a sport, and if we can take some pressure from our small game, we think it is very well worthwhile. We do not think of the fox as game, at least in our law. The fox is not a game animal in our law; it is considered a predator.

DR. FALLIS: Does that answer your question?

MR. BARRON: The first, what damage does the fox do, has not yet been answered.

DR. LATHAM: I am sorry. We have made many studies of the stomach contents and so forth of the fox, a great many in different parts of the state. There is no question but what foxes destroy much game. I am not prepared, however, to say to what extent their depredations control the population of a certain game animal at hunting time. In other words, I don't know the effect upon the hunting kill. Does that answer your question?

MR. BARRON: Yes.

DR. FALLIS: Some other questions?

MR. RICHARD BORDEN (Massachusetts): It seems to me that the very detailed research that you made would have been better spent on an educational program to give the people of Pennsylvania a greater understanding of wildlife although some of this predator group must be controlled. Don't you agree?

DR. LATHAM: Yes I am inclined to agree. We are faced, of course, with hunter pressure, group pressure, as any other state is; and particularly within the last year when our largest disease outbreak occurred, it was almost necessary to do something with the fox.

The bounty system remained in effect during that time, and we took other measures; but of the several species we feel that the fox is probably the one that requires a certain amount of control. That is, if any should be eliminated, the fox would be the last one from our ecological studies and our food-habits studies.

A VOICE: Is the Pennsylvania Commission making any attempts to educate the public to the fact that they may be wasting a lot of their own money on this bounty system? I frequently read the Pennsylvania News, and I don't see anything in there that would indicate they are attempting to educate the public.

DR. LATHAM: Except, of course, where we released a special issue of our game news which was devoted entirely to the predator question, and we hope that our hunter friends would begin to see there was more to game management than just killing.

We have put out two other technical bulletins on predators, and then various times we do have news releases and moving pictures covering the subject.

DR. CHEATUM: I think I see from running through Dr. Latham's paper that he is faced with a *de facto* situation, that he is trying to live with that situation, and he is trying to do with the least amount of money that is appropriated for the state bounty system.

We will go next to the paper by William Longhurst and James R. Douglas of California. In the West there is always the problem of direct conflict on the range between big-game animals and domestic stock. Carried with this conflict on the range itself is the problem of the transmission of parasites and diseases between the two.

Bill Longhurst will make this report which bears on this question. Dr. Longhurst.

PARASITE INTERRELATIONSHIPS OF DOMESTIC SHEEP AND COLUMBIAN BLACK-TAILED DEER

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In the north coastal portion of California, numerous flocks of domestic sheep share common ranges with the native Columbian black-tailed deer. Living as they do in close association on the range and with quite similar foraging habits, it is logical that they should be exposed to many of the same parasites.

In a previous statewide survey of deer management problems (Longhurst *et al.*, 1952), a summary of diseases and parasites reported from California deer was compiled. In this report the losses from stomach and intestinal worms were recognized as the foremost deer disease problem in the state. The area where deer losses from these nematodes are epizootic was roughly defined as the coastal strip from San Francisco Bay northward to the Oregon line and inland to include the Napa Valley and the drainages of the Russian, Eel, and Mad Rivers.

Major sheep morbidity and losses from parasitism have also been known from this part of the state, but to date no very detailed study of sheep parasites under range conditions has been carried out.

The present study of sheep- and deer-parasite interrelationships was conducted at the Hopland Field Station of the University of California College of Agriculture located in southeastern Mendocino County some 60 miles north of San Francisco Bay. The field station is set up primarily for experimental sheep range management. It covers an area of nearly 4,700 acres sloping upward on the east side of the Russian River Valley with elevations ranging from 500 to 3,000 feet. Cover is typical of this section of the state, for the most part consisting of a grass and oak-woodland association intermixed with patches of chaparral. Zonally it is predominantly Upper Sonoran with occasional traces of coastal Humid Transition vegetation such as Douglas fir and madrone.

The principal objectives of the study were to determine the kinds of parasites affecting sheep and deer on the field station, variations in numbers with season and with the age of the host, and the relative importance of their effects on the host.

Since the life history and pathology of most of the parasites concerned in this study are quite well covered in the literature, only especially pertinent items will be discussed in this paper.

We here wish to express our appreciation to Dr. Norman F. Baker, Mrs. L. Eisenhower, and Mrs. F. V. Williams of the Veterinary Science Department at Davis for their generous aid in identifying a large number of the parasites collected during this study; to Dr. Deane Furman of the Department of Entomology and Parasitology of the University of California at Berkeley and Dr. E. W. Jameson, Jr., of the Department of Zoology at Davis for identifying certain of the ectoparasites; to Dr. W. C. Weir of the Department of Animal Husbandry at Davis for furnishing the worm-free lambs which were infected with nematodes from deer; to the California State Department of Fish and Game for the issuance of the deer-collecting permit which helped make the study possible; to Merton N. Rosen and John Azevedo of the Fish and Game Disease Laboratory for their helpful suggestions and assistance with the autopsy work; to Dr. A. Starker Leopold of the Museum of Vertebrate Zoology of the University of California at Berkeley for reviewing the manuscript; and to personnel at the Hopland Field Station for assistance with the field work.

METHODS

Field observations commenced in November, 1951, and continued through January, 1953. An effort was made to determine the status of the deer population and the range through monthly herd composition counts and examination of forage plants, particularly browse species. Dead deer found on the range were checked for sex, age, and, where possible, time and cause of death. Most of the data on parasites, however, were gathered from a series of autopsies of sheep and deer which started in January, 1952, and were carried on to the end of the study. During this period a total of 63 sheep and 81 deer was examined. Additional information on helminth infections was also obtained from fecal examinations.

Specimens of both sheep and deer were collected on the range by shooting. As soon as possible after collection, the carcasses were transported to the laboratory at the field station headquarters for autopsy. For the most part young animals were collected as they were most likely to be affected by parasites, but an adequate sample of various age classes was obtained. Animals found dead on the range were also brought in for autopsy if they were sufficiently fresh. Table 1 gives the number of specimens examined by month with their ages and sexes.

Samples of all parasites found were saved for identification and estimates were made of numbers if they ran into the hundreds or thousands and it was impractical to make total counts. Pathological conditions were likewise noted and recorded.

Fecal examinations were made for helminth eggs and larvae using

TABLE 1. AUTOPSY RECORD[1]

	Sheep				Deer			
	Lambs	Yearlings	Adults	Totals	Fawns	Yearlings	Adults	Totals
1951								
Nov.							1	1
Dec.							1	1
1952								
Jan.		3	1	4	6			6
Feb.		5		5	4	2	1	7
Mar.		5		5	1	2	3	6
Apr.	4	1		5	3	3	3	9
May	4		2	6		4	1	5
June	4		1	5	4		1	5
July	6		3	9	2	1	3	6
Aug.	5			5	3	11	1	15
Sept.	5			5	3	1	1	5
Oct.	5			5	2		3	5
Nov.	5			5	2	1	2	5
Dec.		3		3	4			4
1953								
Jan.			1	1	1			1
Totals	38	17	8	63	35	25	21	81

[1]Lambs were considered yearlings after December 1. Fawns were considered yearlings after May 1.

standard methods of flotation and sedimentation with sodium bichromate. Likewise Stoll counts to determine the number of eggs per gram of feces were made whenever clinical infections of nematodes were indicated.

Deer numbers were calculated by using an index system, very similar to that described by Kelker (1940), based on data derived from herd composition counts and records of deer losses. The adult:fawn ratio was taken in November, 1951, before winter losses began, and again in April, 1952, after the period of loss but before the 1952 fawns arrived. A similar ratio was obtained from the carcasses of deer found dead on the range during this period. Using these three ratios plus an estimate of the total loss, it was possible to arrive at the approximate number of deer which necessarily would have been present to conform with the observed changes in ratio. Obviously the greatest possibility for error in this system was in not estimating the loss on the range correctly. However, a rather careful search for carcasses was carried out and we believe that our estimate of loss was fairly accurate and on the conservative side.

RESULTS

Nutrition and losses: The close correlation between the nutritional state of the host and the success of many parasite infections has long been recognized (Freeborn and Stewart, 1937) and it was therefore necessary to examine the forage situation for both deer and sheep.

Field observations soon showed deer numbers to be very high on the field station. It was also apparent that the range was overstocked with both sheep and deer and showed scars of many years' past abuse. A marked browse line was evident on almost every available tree and shrub; grass and herbaceous vegetation were badly depleted and in a low successional stage; and both gully and sheet erosion were advanced and active.

At this point it should be noted that the University only took possession of the property in July, 1951, and operated it at the same sheep-stocking rate for the first year as had been practiced under the former private ownership. During this first winter 1,024 ewes with their lambs were on the range. The lamb crop at weaning time in May, 1952, averaged 83 per cent. In June the breeding herd was reduced to 778 ewes, and a rotational grazing program, along with range reseeding and fertilization trials, was started for range improvement.

The sheep received supplements of alfalfa hay and cottonseed meal from December to March, 1952. Supplemental feeding was started again September 15 and continued through the winter of 1952-53. From July through mid-September during the breeding season, the sheep were confined largely to cultivated pastures on the field station, totaling some 88 acres of wheat and oats and 35 acres of Sudan grass, and were then fed alfalfa hay when forage was depleted in these fields.

Deer, on the other hand, obtained relatively little supplementary feed with the exception of those individuals which used the grain and Sudan plantings prior to the time sheep were turned in. It is doubtful if as many as 100 deer were thus benefited.

Generally sheep foraged more on grass and herbaceous vegetation than did deer, but both animals fed almost exclusively on grass and herbs from November, when fall rains brought up the new growth, until mid-March. It was during this period that deer deteriorated in condition and suffered heaviest losses. Then as new sprouts emerged on the chamise and other browse species, deer began to take more of them and losses decreased. Sheep took relatively little browse until the annual range forage started to dry up in May. Through June and July deer lived almost exclusively on browse, and sheep also took a considerable quantity. In August acorns began dropping, and deer rapidly shifted over to them. Acorns and some browse formed the bulk of the deer's diet until November when new grass again started. Sheep ate some acorns, but much less than deer. The balance of their diet during this period was made up of dry grass and some browse.

In November, 1951, deer numbers on the field station were estimated at slightly over 600 head. Losses started in the latter part of December and continued through the early part of April, 1952. A careful

TABLE 2. CARCASS COLLECTION OF DEER WHICH DIED FROM NOVEMBER, 1951, THROUGH APRIL 1, 1952.

Age in Years	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+	Totals	Per cent of Total
♂♂	51	4	3					1	2	61	54
♀♀	24	3	1	2	2	2	3	4	10	51	46
Totals	75	7	4	2	2	2	3	5	12	112	
Per cent of total	67	6	3	2	2	2	3	4	11		100

search for carcasses during and after this period netted 110. Table 2 gives a breakdown on the sex and age classes of these carcasses.

Table 3 indicates the progressive change in adult:fawn ratio which was a consequence of 62 per cent of the total deer loss being fawns. In order to calculate deer numbers from the change in adult:fawn ratio, it was necessary to consider the deer which died from accidents (mostly hung up in fences) and those which were collected during this period as being part of the total loss. Actually 68 per cent of the deer which died on the range were fawns.

On the basis of the number of carcasses found, a conservative estimate of the total loss on the range was finally placed at 200 head or about one-third of the November population.

During the period of heaviest losses, from December through March, individual deer had rather small home ranges as judged by the movements of recognizable individuals. Most deer probably spent the winter on areas of less than 40 acres. In late April, however, when browse species were sprouting rapidly, there was a general movement to higher chaparral-covered summering areas above the field station. This upward shift, which could hardly be called a migration since

TABLE 3. DEER HERD COMPOSITION RATIOS

	No. Deer Classified	Bucks per 100 Does	Fawns per 100 Does	Fawns per 100 Adults	Remarks
1951					
Nov.	177	23	63	51	
Dec.	300	25	50	40	
1952					
Jan.	145			37	Antler shedding started
Feb.	241			24	
Mar.	239			18	
Apr.	187			15	
May					No count made—fawning
June	225	49	48	34	Some fawns not yet following does
July	227	50	51	36	
Aug.	203	26	55	45	Hunting season—buck count low
Sept.	216	29	51	41	Hunting season—buck count low
Oct.	222	41	53	40	Rut
Nov.					No count made
Dec.					No count made
1953					
Jan.	206			38	Antler shedding started

most deer moved less than a mile, was completed by early May with at least three-quarters of the surviving winter population leaving the field station.

Losses during the winter were decidedly heavier on the portions of the range where deer wintered on grassland interspersed with a stand of mature oaks which afforded little browse. Relatively few deer died in or about chaparral patches where both grass and herbaceous plants as well as browse were available.

Another bit of evidence on the general debilitated state of the deer herd was the general lack of breeding among the yearling does which should normally have been pregnant for the first time. Even some does in the two to three year age class failed to breed. This reproductive failure was traceable to a lack of ovulation which in turn has been related to poor range condition by Cheatum and Severinghaus (1950).

Generally sheep losses were not abnormal for this section of the country even though the winter was above average in severity. In one pasture of some 570 acres, a flock of 95 head of yearling replacement ewes spent the entire winter without supplementary feed and suffered no losses. There was virtually no available browse in this pasture and both sheep and deer subsisted almost entirely on grass and herbaceous forage. The sheep came through the winter in relatively good condition and progressively increased their fat reserves. On the other hand, 12 deer carcasses were found in this pasture and it was not an area where carcasses were particularly concentrated.

Autopsy data together with field observations indicated that malnutrition coupled with multiple nematode infections, particularly in the abomasum, small intestine and lungs, probably accounted for most of the losses among fawns. Older deer usually carried few worms and their deaths appeared more directly traceable to uncomplicated malnutrition. Deer over six years of age showed excessive wear on their teeth, which undoubtedly contributed to the higher mortality in the older age classes.

Digestive tract measurements. In an effort to determine why sheep were better able to survive competition on a grass and herbaceous diet, measurements were taken of the digestive tracts of several sheep and deer. Lengths of various sections of the intestinal tract were taken as well as the volume content of the four stomach compartments and the intestines. The figures obtained are shown in Table 4.

It should likewise be mentioned here that K. Sayama, a graduate student in zoology at the University of California at Berkeley, while gathering material at the field station for his doctoral thesis on the rumen protozoa of deer, determined that there was a marked differ-

TABLE 4. MEASUREMENTS OF THE DIGESTIVE TRACTS OF DEER AND SHEEP

Age: Years	Age: Months	Sex	Live Weight (Pounds)	Lengths of Portions of the Intestinal Tract: Small Intestine (Feet)	Caecum (Inches)	Large Intestine (Feet)
			DEER			
0	1	♀	20	27	4	17
0	11	♀	35	38	8	14
0	11	♂	52	38	4	16
1	0	♀	51	43	7	15
1	0	♀	54	43	4	15
1	11	♂	64	44	8	15
1	11	♂	74	55	11	18
2	11	♀	68	45	7	17
3	11	♀	82	43	10	17
5[1]	5	♀	67	39	10	17
			SHEEP			
0	4	♀	33	67	9	15
0	4	♀	45	77	11	13
0	4	♀	55	79	12	17
0	5	♀	....	75	12	16
0	6	♂	59	98	11	17
1	2	♀	69	91	13	17
5	5	♀	....	80	24	21
5[1]	7	♀	77	85	14	19

[1]Volumes in cubic centimeters of the digestive tracts of the last deer and last sheep listed above.

		Rumen	Reticulum	Omasum	Abomasum	Small Intestine	Caecum	Large Intestine
Water displacement of organ with food contained	Deer	6,300	190	80	200	900	200	700
	Sheep	8,000	200	400	1,200	1,200	500	1,300
Filled to capacity with water	Deer	7,500	140	60	180	3,400	300	1,400
	Sheep	12,000	700	300	1,500	7,100	1,000	2,500

ence in the kinds of these protozoa present in sheep and deer. This could well have an effect on their relative abilities to digest certain kinds of forage.

From these data it is readily apparent that for their size sheep can handle a larger volume of forage and can probably digest it more efficiently in their longer intestinal tracts. The net result is that deer appear to be less adapted than sheep to exist on a winter diet of grass and herbs and therefore may be more prone to suffer from the effects of parasitism.

Weather relationships. The life cycle of most of the nematodes found to be of importance in this study is one of direct infection with no intermediate host involved. Eggs laid by adult worms in the digestive tract and lungs pass out with the feces. The larval worms hatch out and, after a series of developmental stages with suitable conditions of moisture and temperature, crawl up on blades of grass and are ingested by a grazing deer or sheep.

Because precipitation is seasonal in this area, usually occurring from October to June, moisture conditions are most favorable for nematode larvae during these months. Both deer and sheep feed to a large extent on grass and herbaceous vegetation during the winter months and hence nematode infections build up during this period. Drying out of ranges through the summer virtually precludes the survival of larvae except around spring seepages where there is green grass.

During the winter of 1951-52, precipitation, mostly in the form of rain with a few brief snow storms, amounted to 47.64 inches. Nearly 30 inches of this fell from December through February. This exceeded the average of 35.35 inches. Likewise the mean temperature from December through March was 46.7° F., which was below the average of 48.1° F. (Precipitation data are from the Ukiah weather station.)

To date, the present winter of 1952-53 has been about equal in precipitation but much milder in temperature than the preceding winter. Since nematode larvae thrive under warm, moist conditions, it would seem that this winter would be more favorable for them. Recent deer losses have been very light, however, and fawns particularly appear to be in much better condition than at this time last year.

Effects on fawns. Five fawns collected in January, 1952, had an average live weight of 34.4 pounds, whereas four fawns taken in December, 1952, averaged 37.5 pounds. Likewise antler development of male fawns, which is a good criterion of condition, could not be detected until January, 1952, on fawns born the previous May. In contrast, male fawns born in May, 1952, showed antler buds by the following August.

As shown in Table 3, fawn survival in January, 1953, of 38 fawns: 100 adults was only slightly better than in January, 1952, when there were 37 fawns:100 adults. In the first place, there were relatively more bucks present in the herd in 1953 than in 1952, largely due to the selectively heavy mortality of does in the winter of 1951-52. Secondly, early fawn survival in 1952 was lower than in 1951 as can be seen by comparison of the ratio of 53 fawns:100 does in October, 1952, to 63 fawns:100 does in November, 1951. Whether this low pre-winter fawn count in 1952 is a result of a poor ovulation rate during the 1951 rut, or heavy post-natal fawn mortality in May, 1952, is not known. At any rate, survival of those fawns which entered the winter has been relatively much better in 1953 than in 1952.

Parasites. A total of 39 kinds of parasites were identified from sheep and deer. They included 1 protozoan, 5 tapeworms, 1 fluke, 18 roundworms, 2 lice, 5 flies, 1 flea, 3 ticks, and 1 mite. Of these, deer were host to 35 species, sheep were host to 24 species, and 20 species were

TABLE 5. PARASITES FOUND IN SHEEP AND DEER

Parasite	Host Sheep	Host Deer	Location	Seasons of Occurrence	Abundance	Remarks
PROTOZOA						
Eimeria spp.—Coccidia	x	x	Small and large intestines	All year	Common—numbers low to moderate	No clinical infections observed
FLUKE						
Fasciola hepatica—liver fluke	x	x	Liver	Most infections in spring	Rare on field station	Formerly abundant, now rare because of control
TAPEWORMS						
Moniezia expansa—double-pored ruminant tapeworm	x	x	Small intestine	All year	Common	
Moniezia benedeni—double-pored ruminant tapeworm	x	x	Small intestine	All year	Common	
Thysanosoma actinoides—fringed tapeworm	x	x	Liver, abomasum, small intestine	All year	Common in sheep; uncommon in deer	Causes jaundice in liver infections
Cysticercus ovis—sheep measle	x	x	Muscles	All year	Uncommon	
Cysticercus hydatigena—bladder worm	x	x	Mesentaries	All year	Abundant in deer; less common in sheep	
ROUNDWORMS						
Strongyloides papillosus—thread worm	x	x	Small intestine	Most infection in winter	Sporadic occurrence	
Oesophagostomum venulosum—nodular worm	x	x	Caecum and large intestine	Most infection in winter	Common	Causes scours in heavy infections
Chabertia ovina—large-mouthed bowel worm	x	x	Large intestine	Most infection in winter	Uncommon	
Bunostomum trigonocephalum—sheep hookworm	x		Small intestine	Unknown	Rare	Not established on field station
Trichostrongylus colubriformis—small thread worm	x	x	Small intestine and abomasum	Most infection in winter	Uncommon	
Trichostrongylus axei—small thread worm	x	x	Small intestine and abomasum	Most infection in winter	Uncommon	Debilitating
Trichostrongylus vitrinus—small thread worm	x	x	Small intestine and abomasum	Most infection in winter	Abundant	Debilitating
Haemonchus contortus—twisted stomach worm	x	x	Abomasum and small intestine	Most infection in winter	Uncommon	Debilitating
Ostertagia circumcincta—brown stomach worm	x	x	Abomasum and small intestine	Most infection in winter	Abundant	Debilitating
Ostertagia trifurcata—brown stomach worm	x	x	Abomasum and small intestine	Most infection in winter	Common	Debilitating
Cooperia oncophora	x		Small intestine	Most infection in winter	Sporadic occurrence	
Nematodirus filicollis—thread-necked strongyle	x	x	Small intestine	Most infection in winter	Abundant	
Nematodirus spathiger—thread-necked strongyle	x	x	Small intestine	Most infection in winter	Common	

Dictyocaulus filaria—sheep lungworm	x	x	Lungs	Most infection in winter	Common in sheep; rare in deer	Debilitating
Dictyocaulus viviparus—thread lungworm		x	Lungs	Most infection in winter	Common	Debilitating
Thelazia californiensis—eye worm		x	Eyes	All year	Common	
Trichuris ovis—whipworm	x	x	Caecum and large intestine	Most infections in winter	Common	
Setaria cervi—body worm		x	Body cavity	Most numerous January-May	Common	Irritating to mesentaries in heavy infections
LICE						
Trichodectes tibialis—biting louse		x	External	Abundant February-April	Seasonally abundant	Irritating to skin in heavy infestations
Solenopotes ferrisi—sucking louse		x	External	April	Rare	
FLIES						
Cephenomyia jellisoni—deer nose bot		x	Nasopharynx and lungs	In lungs—June, December In nasopharynx—December, May	Common	
Oestrus ovis—sheep nose bot	x		Nasal passages	Spring	Rare	
Cuterebra sp.		x	Under skin of back	August	Rare	
Lipoptena depressa—louse fly		x	External		Common	Irritating to skin in heavy infestations
Neolipoptena ferrisi—louse fly		x	External		Common	Irritating to skin in heavy infestations
Melophagus ovinus—sheep ked	x		External	Spring	Rare	
FLEA						
Pulex irritans—human flea		x	External	All year—most numerous April-August	Common	
TICKS						
Dermacentor occidentalis—Pacific coast tick		x	External	All year—few—June-August	Common	Irritating to skin in heavy infestations
Ixodes pacificus		x	External	All year—few—June-August	Common	Irritating to skin in heavy infestations
Ornithodorus hermsi		x	External	Spring	Rare	
MITE						
Euschongastia sp.—chigger		x	External—mostly about head and neck	Abundant—December-February	Seasonally abundant	Irritating to skin in heavy infestations
Neoschongastia sp.—chigger		x	External—mostly about head and neck	Abundant—December-February	Seasonally abundant	Irritating to skin in heavy infestations

common to both hosts. Table 5 lists the parasites which were found along with a summarization of their host specificity, seasons of occurrence, abundance and importance.

Roundworms. Even though this parasite list is considerable, only a few species were found to have material effects on the hosts in causing morbidity or mortality. Others were relatively benign or only became important in exceptional cases. For the most part, the parasites which had the most serious effects were nematodes belonging to the genera *Ostertagia, Trichostrongylus* and *Dictyocaulus.*

Ostertagia circumcincta and *O. trifurcata* were the most numerous worms found in both sheep and deer. They were usually located in the fourth stomach or abomasum but were also found in the small intestine, though in lesser numbers. *O. circumcincta* was more common than *O. trifurcata* although mixed infections with *O. circumcincta* dominating were the rule. These worms were found in 54 sheep and 52 deer.

Of the three species of *Trichostrongylus* found, *T. vitrinus* was by far the most prevalent, usually inhabiting the small intestine and occasionally the abomasum. *T. axei* and *T. colubriformis* were infrequently encountered but in some animals were the dominant species.

These nematodes of the abomasum and small intestine were considered to be the most important group in contributing to debilitation in lambs and debilitation and mortality in fawns. No sheep deaths were noted where parasites were considered to have been the primary cause. However, most fawn losses during the winter of 1951-52 were considered attributable to multiple helminth infections. The deleterious effects of these nematodes on sheep have long been recognized and are well described by Morgan and Hawkins (1949). Most of them cause anemia of the host through their blood-sucking habits.

A so-called "self cure" or acquired immunity to nematodes, as noted by Morgan and Hawkins (1949:6) was found to be built up by sheep at around 14 to 16 months of age. A similar immunity was evident in deer when they were 12 to 14 months old. This immunity was most pronounced in both animals to infections of nematodes in the abomasum and small intestine and less so to infections in the large intestine and caecum. Likewise immunity to some species could apparently later be broken down if a sheep or deer suffered from excessive malnutrition or a bacterial infection.

In deer, lung worms were most frequently found in fawns. The thread lung worm of cattle (*Dictyocaulus viviparus*) was identified from 20 deer, of which there were 11 fawns, 3 yearlings and 6 adults. Heavy infections (over 50 worms) were not found in adult deer.

Mixed infections of *Dictyocaulus viviparus* and the sheep lung worm (*D. filaria*) were present in two fawns and two yearlings. One of these fawns was found dead and the other fawn and both yearlings were very weak and sick. All had additional infections of stomach and intestinal worms. It is doubtful that *D. filaria* played other than a contributory role toward the death or morbidity of these animals and it is more logical to assume that deer are normally quite resistant to this species and infections only become established when the animal is in a poor state of health.

Only *D. filaria* was found in sheep, and here again heavy infections were confined for the most part to lambs and yearlings. Infections of *D. viviparus* tended to form more abscesses in the lungs than did *D. filaria*. One five-year-old ewe had a heavy infection, but she was in very poor condition resulting from an infection of *Corynebacterium pyogenes* as well as heavy infections of stomach and intestinal worms. It appeared probable in this instance that her acquired resistance to nematodes may have been broken down as a result of the bacterial infection.

Infections of *Corynebacterium pyogenes* and *C. pseudotuberculosis* were found in both sheep and deer but the incidence was difficult to determine. However, such infections undoubtedly contribute to the mortality rate, both as primary causes of death or as secondary debilitating factors which break down resistance to parasites.

Certain of the other parasites found during this study could have serious effects on sheep and deer if they were present in sufficient numbers. In California, infections of the twisted stomach-worm (*Haemonchus contortus*) have not been found to be as severe in sheep as those from the Midwest and eastern states. It was only found sporadically on the field station. At the beginning of the study, this worm had evidently not become well established on this range. As nearly as could be determined it was brought in with a flock of replacement ewes shipped from irrigated pastures in the Sacramento Valley in October, 1951. It was first found in a deer in February, 1952, in the pasture where these ewes had been held. Subsequently it was found in four other deer and several lambs in pastures which had been occupied by these particular sheep. The maximum number of twisted stomach-worms found in any one animal was only 27, and it is possible that climatic factors are not favorable for it in this locality. Nevertheless the rapid transfer of this parasite from sheep to deer is evidence of the close interrelationship of the two host animals as regards mutual parasites.

The nodular worm (*Oesophagostomum venulosum*) can also have serious effects if it is present in sufficient numbers but the most found on the field station were 110 in a sheep and 80 in a deer. However, most instances of scours in both sheep and deer were correlated with the presence of this worm. Even with heavy infections of other worms in the abomasum and small intestine, animals rarely showed scours.

The other worms which were usually found in the caecum and large intestine, *Trichuris ovis* and *Chabertia ovina,* were never present in sufficient numbers to be of importance. On the other hand, two lambs from irrigated pastures on nearby ranches were autopsied and both carried very heavy monospecific infections of *C. ovina* in their large intestines. From this it would appear that environmental conditions on the experimental range were not particularly favorable for this species. In contrast, conditions on irrigated pastures which were moist during the summer evidently did favor *C. ovina.* Actually most nematode larvae tend to thrive better under warm, moist conditions, but since hill ranges are only moist in winter and spring, only those species which can tolerate the winter temperature survive.

Two species of thread-necked strongyles, *Nematodirus filicollis* and *N. spathiger,* were found to be abundant. They usually occurred in mixed infections in the small intestine with *Trichostrongylus* so that it was difficult to separate out their effects. Usually they are not considered to have detrimental effects on sheep even with very heavy infections (Morgan and Hawkins, 1949). In most samples *N. filicollis* outnumbered *N. spathiger* about three to one. Likewise they were often the first species to show up in new infections in fawns.

Cooperia oncophora and the hookworm, *Bunostomum trigonocephalum,* were encountered sporadically in sheep. It is doubtful if environmental conditions were favorable enough to permit the establishment of the sheep hookworm in this area as it was only found in sheep which had been shipped in from the Sacramento Valley and apparently was not transferred to animals raised on the field station.

Strongyloides papillosus was a nematode that occurred occasionally in both sheep and deer, but never in sufficient numbers to be significant.

Although eye worms (*Thelazia californiensis*) have been reported from sheep and a number of other hosts including deer and man, none was found in sheep at the field station. They were fairly common in deer, however, and 29 cases were discovered. Since very little is known of the life history of this species, it seems worth while to mention that they were found to infest fawns first in late July when the fawns were about three months old. Cases in older deer occurred throughout the year. Likewise in a series of 17 California jack rabbits autopsied from March through August, three cases of eye worms were discovered, all during March. So far as is known, this is the first host record reported for these worms in rabbits. The only pathology noted was opaque corneas in one fawn and one rabbit.

The body worm (*Setaria cervi*) was another species which exhibited strict host specificity and was found only in deer. Incidence was high from January through May, 1952, but dropped off sharply thereafter. During this period 21 of 35 deer examined were infected. From June, 1952, through January, 1953, only 6 of 47 deer were infected. Three fawns were found with exceedingly heavy infections (over 100 worms) which caused considerable irritation to their mesentaries. A fawn presumably born in May carried an infection the following August.

Experimental roundworm transference. Even though field and laboratory data indicated that nematodes were transferred between deer and sheep, it was of value to rule out the possibility of host specific biological strains of worms. Therefore a test was set up to infect worm-free lambs with nematode larvae cultured from deer feces.

Five lambs, raised in a cement-floored pen on a milk diet with mineral additives, were used in the test. On March 14, 1952, two lambs were infected with nematode larvae cultured from deer feces and three were kept as controls. After infection the five were kept on dry-lot feed to reduce the possibility of further infection. Fecal samples were checked for nematode eggs by flotation, once before infection and at eight intervals before all five were autopsied on August 22, 1952.

Table 6 indicates the species of nematodes found in the deer from which fecal samples were taken, nematode eggs identified from the lambs' feces, and nematodes recovered from the lambs on autopsy.

The only species of nematodes present in the deer which were not recovered from the lambs when they were autopsied were *Dictyocaulus viviparus* and *Trichostrongylus colubriformis*. However, *Trichostrongylus* eggs were identified from the fecal samples.

Eggs of *Trichuris ovis, Strongyloides papillosus* and *Trichostrongylus* sp. were found in one of the control lambs, but because of difference in the life cycle of the first two species from the rest of the nematodes involved, their appearance was not considered significant. Infections of *T. ovis* occur through ingestion of embryonated eggs, and larvae of *S. papillosus* can gain entrance through direct penetration of the skin. This makes it more possible for infection to take place in a dry lot, whereas the other species would find it more difficult to complete their life cycle. Only a very few eggs of *Trichostrongylus* were found in this control lamb and it is probable that in spite of the dry-lot precautions some transference took place.

Flukes. The liver fluke, (*Fasciola hepatica*) is a form with a serious potential, especially for sheep. Flukes were reportedly very numerous in this area in former years, but systematic control of the intermediate snail hosts with copper sulfate has virtually eliminated them from the field station. The only case of fluke discovered was in a doe which was

TABLE 6. PARASITES INVOLVED IN EXPERIMENTAL TRANSFER OF NEMATODES FROM DEER TO SHEEP.

Species of Parasites
In deer from which fecal cultures were obtained: *Ostertagia circumcincta* *Trichostrongylus colubriformis* *Dictyocaulus viviparus* *Haemonchus contortus* *Nematodirus filicollis* *Oesophagostomum venulosum* *Chabertia ovina* *Trichuris ovis*
In worm-free lambs before infection—fecal flotations: *Eimeria* sp.
In lambs after infection—fecal flotations: *Eimeria* sp. *Ostertagia circumcincta* *Trichostrongylus* sp. *Oesophagostomum venulosum*
In control lambs—fecal flotations: *Eimeria* sp. *Strongyloides papillosus* *Trichostrongylus* sp. *Trichuris ovis*
In infected lambs—autopsy: *Ostertagia circumcincta* *Haemonchus contortus* *Nematodirus filicollis* *Oesophagostomum venulosum* *Chabertia ovina* *Trichuris ovis*
In control lambs—autopsy: *Trichuris ovis*

collected near a small lake that had not been treated with copper sulfate because of the fish it contained. Sheep were fenced away from the lake, and this evidently provided them sufficient protection.

In 1942 when the ranch was still under private ownership, 260 head of sheep were reported lost through fluke infections and subsequent attacks of Black disease. The causative organism of Black disease, *Clostridium novyi,* has been shown to be a normal inhabitant of the liver, but when the liver is damaged by migrating flukes the bacteria become active and secrete exotoxins which are extremely lethal. Deer apparently do not contract Black disease and to the authors' knowledge suffer no mortality from infections of this fluke alone without additional infections of other parasites.

Tapeworms. Both deer and sheep were found to be definitive hosts for two species of the double-pored tapeworm (*Moniezia expansa* and *M. benedeni*). Generally infections were not heavy and it was exceptional to find over five worms in any one animal. Some individual worms grew to considerable length and one specimen of *M. expansa* from a lamb was found to be slightly over 11 feet long. Of the animals autopsied, 15 deer and 32 sheep were found infected. The youngest fawn found with an infection was three months of age. No pathology was observed. This is similar to the findings of other workers (Morgan and Hawkins, 1949).

Sheep were the principal definitive host for the fringed tapeworm (*Thysanosoma actinoides*). Seventeen cases were found in sheep and only seven in deer. No pathological conditions were found when infections were limited to the small intestine or abomasum, but when these tapeworms invaded the bile ducts of the liver, there was often sufficient mechanical obstruction to produce noticeable jaundice.

Deer and sheep were the intermediate hosts for the tapeworms, *Taenia hydatigena* and *T. ovis.* The intermediate stages of these cestodes, the cysticerci or so-called "bladder worms," were the forms present. Actually *Cysticercus ovis* was rather rare and was found in but four sheep and one deer. Conversely *C. hydatigena* was quite common and was present in 16 sheep and 53 deer.

Protozoa. Several unidentified species of coccidia of the genus *Eimeria* appeared in many of the fecal samples. Usually they were only present in small numbers and no clinical infections were noted.

Ectoparasites. Deer were much more heavily infested with ectoparasites than were sheep, both as to numbers of species and numbers of individuals. This group of parasites likewise exhibited complete host specificity.

The only cases of ectoparasites in sheep were one ewe carrying a few keds (*Mellophagus ovinus*) and five other sheep infested with larvae of the nose bot (*Oestrus ovis*). No adverse effects were noted.

In most cases ectoparasites did not have particularly serious effects on deer and usually appeared only to be irritating. Exceptions were heavy infestations of biting lice (*Trichodectes tibialis*), which were found on several fawns and yearlings from early February through April. These lice persisted in diminishing numbers into August. Only a very few were observed on older deer, which were usually in better physical condition than the fawns and yearlings. When present in large numbers, they caused considerable dermal irritation and hair sloughing.

In late April one fawn was collected with a mixed infestation of biting lice and sucking lice (*Solenoptes ferrisi*).

Trombiculid mites (*Euschongastia* sp., and *Neoschongastia* sp.) also caused much irritation and hair sloughing, particularly about the head and neck, when there were heavy infestations. As with lice, they were seasonally abundant and were most numerous from December through February.

The larvae of two flies were found infesting deer. One, *Cuterebra* sp., was only recovered from a single fawn in August. Two mature larvae were encysted under the skin of the fawn's back, and there was evidence that another had recently dropped out. This fly normally attacks rodents and so far as is known, this is the first record for deer in the state.

The other fly in question was the deer nose bot (*Cephenomyia jellisoni*). The cycle of its infestation apparently began in the late spring during May and June. The adult flies probably laid their eggs about the deer's nose and mouth, and by late June almost every deer examined had numbers of very small larvae (1 to 2 mm.) in the larger bronchi of its lungs. These small larvae remained in the lungs and developed until early December, when they had obtained a length of about 10 mm. At this time they began migrating up to the nasal passages and nasopharynx and attached themselves there. The maximum number found were 47 in a fawn in January, 1953. By mid-May most of the larvae had reached maturity and dropped out to pupate in the soil. There was some divergence in the timing of this cycle, and a few small larvae still remained in the lungs as late as January.

Two species of louse flies (*Lipoptena depressa* and *Neolipoptena ferrisi*) occurred commonly on deer during most seasons but were especially numerous from May through July. As with lice, the heaviest infestations were found on the deer in poorest condition, namely young animals and nursing does. Mature bucks carried relatively few flies. Louse flies undoubtedly contributed to morbidity through their bloodsucking habits.

Fleas were found on deer throughout the year, but were most numerous from April on through the summer into August. Only one species, the human flea (*Pulex irritans*) was encountered.

Three species of ticks were identified during the study. *Dermacentor occidentalis* and *Ixodes pacificus* were the most common. There was only one record of *Ornithodorus hermsi.* Some ticks were present at all seasons. but their numbers were especially low from June through August. They were never present in numbers great enough to cause much irritation.

DISCUSSION

Probably the two aspects of this study which have most significance are: First, the parasite transference between sheep and deer, and second, the relation of the physical condition of these animals to parasitism.

The similar foraging habits of sheep and deer at the season of the year most favorable for nematode infection provide ample opportunity for transference of all host-tolerant species. Field and autopsy data indicated that nematodes infecting the abomasum, small intestine and lungs had the most serious effects. Infections were built up in the fall and winter when moist conditions allowed nematode larvae to complete their life cycle.

The majority of fawns were born during the first two weeks in May and subsisted chiefly on their mother's milk until the grass and herbaceous vegetation had dried up in June. Most of the green forage they consumed during the summer was browse, and they generally did not become infected with gastrointestinal worms until the following December. Those fawns which survived their first winter acquired a resistance to nematodes so that relatively few worms were carried over the summer in deer. Sheep acquired a similar resistance at approximately the same age, but because lambs were born in December and January, they accumulated a considerable worm burden before summer. Thus any lambs kept over summer as replacements carried their worms through to reinfect the range the following winter. It is probable, however, that even though worm numbers were low in most older sheep and deer, there were sufficient present, considering the larger number of animals in these age classes, to provide the major source of reinfection. Another source of worms. particularly new species, was in sheep brought in from other localities.

Endoparasites, and to some extent, ectoparasites appear to exhibit a correlation in their numbers and in their effects with the physical condition of the host. Animals in poor condition have larger numbers of parasites and are less able to withstand their effects. Host condition is most likely to be influenced by nutrition. Nutritional status in turn is largely determined by the availability of food and bodily demands for maintenance, growth, and reproduction. Young animals, therefore, because of the demand on their nutritive intake for growth, are in a relatively poor position to withstand attacks by parasites. Likewise they have no acquired immunity to parasites and their small size and lack of experience in foraging make it difficult for them to compete with older animals for food.

The reasons for selectively high male fawn mortality are rather obscure although male animals in general are known to have a slightly higher metabolic rate than females, and their food requirements may therefore be a trifle greater.

Sheep, with their larger digestive tract, appear to have an advantage over deer when competing on a grass range. Deer also seem to require a certain amount of browse to supplement a grass and herbaceous diet in winter. Such a browse supplement may be necessary to deer as a source of cellulose. Grass and herbaceous vegetation are notably low in cellulose and carbohydrates at this season, and cellulose is important to ruminants as a substitute for carbohydrates as a source of energy.

Whitlock (1949) has reported that sufficient caloric intake is especially important in the prevention and control of trichostrongylidoses and therefore it may well be that deer suffer from lack of energy when forced to pass the winter on a diet of grass and herbs. A particularly cold winter would tend to accentuate this effect through raising the amount of energy necessary to maintain body temperature. In this regard, too, the small size of young animals would work to their disadvantage in that their heat loss would be proportionately greater than for larger animals since their surface area in relation to their volume is greater.

A reduction in numbers of sheep and deer with consequent reduction in competition for forage had a considerable effect in producing healthier fawns and reducing winter deer losses.

Nematode densities, in addition to being governed by the health of individual host animals, are to a considerable extent dependent upon suitable environmental conditions for transference from host to host. It is logical therefore that, with a gradient toward lower precipitation inland from the coast, there should be a parallel gradient in worm numbers in those species which are dependent upon moist conditions to complete their life cycle. Actually the field station at Hopland is near the eastern limit of the area where worms in sheep and deer constitute a problem on the range. Therefore results obtained during this study might not be entirely applicable even to nearby areas with differences in precipitation and temperature.

MANAGEMENT

Parasite control under the range conditions existing at Hopland can probably best be attacked by taking measures to improve range condition. Foremost among such measures is the maintenance of proper stocking rates for both sheep and deer.

Chemical control of nematodes in sheep has proven effective, however, and phenothiazine has been reported to be the most useful agent (Britton *et al.*, 1943; Stewart, 1945). Successful control with phenothiazine includes both therapeutic doses given as a drench or pellet according to body weight, and prophylactic doses in a salt mixture. Obviously such a program is not practical for deer. On the other hand, it is probable that a reduction of nemtaodes in the sheep flock would be of indirect benefit to deer in that the rate of infection would be lowered. By the same token, reducing the incidence of helminths in deer.

through regulating numbers to what the range will suport in healthy condition, would benefit the sheep.

SUMMARY

A study of sheep- and deer-parasite interrelationships was carried out at the Hopland Field Station of the University of California College of Agriculture. Field and laboratory work extended from November, 1951, through January, 1953. Principal emphasis was on determining the kinds of parasites present, seasonal fluctuations in numbers and their effects on their hosts.

Data were gathered from field observations, fecal examinations and autopsies of 63 sheep and 81 deer.

Thirty-nine kinds of parasites were identified from sheep and deer and of these, 20 species were found common to both animals. Nematodes belonging to the genera *Ostertagia, Trichostrongylus* and *Dictyocaulus* which infected the abomasum, small intestine and lungs respectively, were considered to have the most serious effects. Parasites contributed to heavy losses among deer, and sheep were also materially debilitated but did not suffer excessive losses.

Lambs were successfully infected with nematode larvae cultured from deer feces.

During the winter of 1951-52 when the range was overstocked with sheep and deer, the effects of malnutrition intensified parasitism. Subsequent reduction in numbers of animals on the range helped reduce deer losses in the winter of 1952-53, even though weather conditions were more favorable for nematode infections.

Chemical control of nematodes is not practical for deer, but it can be effectively applied to sheep. Such chemical control in sheep should reduce the rate of infection in deer. However, the most promising parasite controls are through improving range conditions and maintaining proper stocking rates for both sheep and deer.

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DISCUSSION

DR. FALLIS: I don't wish to take the time of the meeting, but I am sure some of you will have questions that you want to ask Dr. Longhurst afterwards. This question of transference of parasites from the wild to domestic species is indeed an important one.

I could not help but wonder whether the nutritional status of the parasites was determined in some of the cases that Dr. Longhurst investigated, and whether it was possible to know how many parasites were found in those animals he found dead, presumably from malnutrition.

STUDIES ON RABBITS AND SPOTTED FEVER

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Recently spotted fever has appeared in rabbit (*Sylvilagus floridanus*) populations in many states and has become an important problem because of the importance of rabbits as a game species. This paper discusses some results of the study of a rabbit population. Although essentially a progress report this paper is presented to call to the attention of game managers some of the problems involved.

Spotted fever was first described in Montana about 1910 and has been studied intensively since that time. The agent is a Rickettsia which is transmitted from mammal to mammal by ticks. Many kinds of mammals and ticks are involved. In many cases the larval stages live on different hosts than do the adult stages. The dog tick feeds on many kinds of mammals and is the chief means of human infection. Rabbit ticks feed exclusively upon rabbits and hence cannot transmit the disease to humans. The larval stages may be carried about by birds, and thus the infection may spread far and wide. The ticks may transmit the Rickettsia to their young through the egg. This hasty summary partially indicates the complexity of the life cycle.

Although the disease was first recognized in the West, the eastern states now have the most cases. North Carolina, Virginia, and Maryland have the highest reported prevalence. In recent years the number of cases has attracted the attention of the health agencies. Unfortunately the disease cannot be controlled with the knowledge at hand. The big problem is the means of transfer of the Rickettsia from rabbit ticks to dog ticks. In part this involves the problem of the hosts for larval ticks.

An opportunity to study these problems arose upon an island on the Chesapeake Bay. The island has about 150 acres of which about 100 are used for pasture and crops. The remainder is in woods and brush.

The history of the rabbit population is known in some detail. Rabbits were present in moderate numbers until 1926 when they died out completely due to a disease, according to the local farmer. The evidence indicates that rabbits were absent from 1946 to 1948. The farmer and several men (John T. Emlen, A. W. Stokes, J. B. Calhoun, and D. E. Davis) saw no signs of rabbits on frequent visits during this time. In the fall of 1948, a male and female were introduced. By the fall of 1951 the rabbits were abundant. Their holes and tracks were common and five to ten could be seen on a hour's walk. Unfortunately lack of manpower prevented an adequate census. However, the abundance can be indicated by the number seen per hour on various dates: Dec. 12, 1951—7 per hour; Feb. 12, 1952—6 per hour; April 10, 1952—5.5 per hour; on May 4 a drive was conducted by seven men who saw 253 rabbits. From this it was believed that about 300 to 350 were present. The farmer reported that about 60 were shot during the hunting season.

The increase also is indicated by examination of owl pellets. A collection of 1,279 pellets from barn owls and great horned owls from 1946 to September, 1951, showed no rabbit remains. In December, 1952, hair was common in pellets. A total of 350 pellets collected during 1951-52 showed about 10 per cent with rabbit hair or bones. Pellets collected this past winter showed about the same incidence. Unfortunately rabbit bones are usually too large to be found in pellets, and the amount of hair is a crude measure of abundance. However, the rapid increase of rabbit remains is an indication of a rapid increase in population.

During 1951 a number of rabbits was collected from the island for studies of disease and other aspects. On May 4, 18 were collected; May 22, 21 were shot; October 10, 26; October 28, 11; and November 8, 18 or a total of 94 rabbits. During the hunting season, 47 were killed.

The blood and internal organs were collected and examined. No evidence of tularemia was found in 15 specimens. Complement fixation tests for spotted fever showed that 27 out of 29 bloods examined were positive. In addition tests for Q fever were positive in three cases. The liver and especially the kidney showed lesions of consistent chronic Rickettsial infection. Several rabbits were parasitized with *Taenia pisiformis,* but no coccidiosis was observed.

The rabbits in early May were heavily infested with rabbit ticks (*Haemophysalis leporis-palustris*) from which Rickettsia were isolated. No dog ticks (*Dermacentor variabilis*) were found on tbe two dogs nor on several cattle.

An estimate of the population on February 3, 1953, indicated that about 100 rabbits were present. Surprisingly few owl pellets were found in contrast to previous years. One carcass of a rabbit that had obviously been killed by an owl was found.

An active program of study is planned for this spring to include determination of the time of emergence of ticks, the age at which rabbits become infected, testing of small rodents for Rickettsia and other aspects. The results thus far indicate that spotted fever may be present at a very high level in populations of apparently healthy rabbits. Furthermore that, in spite of the high prevalence of spotted fever in rabbits, no human cases were reported from the many people that frequent the island. The implications for the game manager who wishes to stock or transfer rabbits are ambiguous. If he transfers infected rabbits and cases of spotted fever occur, then he may be blamed for spreading disease. But if the rabbits in an area already have spotted fever, the introduction of more infected rabbits can not properly be blamed for human cases. But the administrator will need to consider his introduction program carefully and consult with health authorities to prevent misunderstandings. It is hoped that in the very near future adequate knowledge will be available to abolish this dilemma.

DISCUSSION

DR. FALLIS: Dr. Davis' paper is now open for discussion. This question of spotted fever is of concern to all of us living in certain areas where this disease is known to occur.

MR. BARRON (Washington, D. C.): The question I have is did you check the pair of rabbits you turned loose to see if they had spotted fever?

DR. DAVIS: I haven't turned loose any rabbits, and the rabbits that have been turned loose haven't been checked.

DR. FALLIS: I wonder, Dr. Davis, whether you have made any attempt to transfer the disease from rabbits to any other animals by having the tick feed on other animals or by injecting the other animals or rodents. What effect did it have on the other rodents in addition to the rabbits on the island?

DR. DAVIS: I hope the answers to those questions will be forthcoming. That work has not been done, but it is an essential part of understanding spotted fever.

DR. FALLIS: Thank you, Dr. Davis. I am sure we will all look forward to the further work that Dr. Davis and his group are doing on this problem, and we will hope to hear something further from them at a future meeting.

A NEW APPROACH TOWARD BOTULISM CONTROL[1]

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INTRODUCTION

It is recognized that among the diseases affecting wildlife, botulism in waterfowl is of major importance. It exerts a positive control on populations which is readily demonstrable on reviewing mortality figures. The bacteriology, symptomatology, and natural history of the disease have been covered extensively in the literature, therefore it is considered unnecessary to review all phases of past work except as they relate directly to control of epizootics.

In spite of the vast amount of research that has occupied investigators for many years, management of an epizootic has not progressed beyond the initial recommendations of earlier workers. In the past the greatest effort has been directed toward "duck rescue," which apparently appeases the public but does not significantly reduce waterfowl mortalities. In recent years the U. S. Fish and Wildlife Service has done a considerable amount of work on control of water levels on permanent waterfowl areas, but the problem of how to cope with temporary water areas had not been solved.

Late in the spring of 1952 it became apparent to the staff of the California Department of Fish and Game Laboratory that, based on past history of the Tulare Lake, the situation was ripe for another outbreak in this area. Accordingly, it was decided to work cooperatively with members of Region I of the U. S. Fish and Wildlife Service in order to plan in advance measures which could be applied to aid in the control of the predicted outbreak. It is emphasized at this time that this preliminary planning was most effective from the standpoint of the amount of control later achieved.

It is further recognized that the Tulare Lake duck botulism problem represented in some respects a somewhat specialized case in that it had three advantages on the side of effective control. These advantages were:

1. Previous work in past decades on this area had given us an adequate history on which to base predictions.
2. There were no major agricultural crops susceptible to depreda-

[1]Federal Aid in Wildlife Restoration Act, California Project 35R.

[2]The authors gratefully acknowledge the cooperation of Clinton H. Lostetter and Adolph Zajanc, U. S. Fish and Wildlife Service, and of personnel of the California Department of Fish and Game.

[3]In the absence of the authors the paper was read by Mr. Ben Glading, director of Game Management, California Department of Fish and Game.

tion in the immediate vicinity that would cause a problem if ducks were displaced onto them.

3. There was an adequate area some distance away to which the waterfowl could be herded.

As a result the authors attempted a new approach to control the losses caused by the disease.

HISTORY

Prior to the adoption of any control measures, it is necessary to be able to predict an outbreak. A knowledge of past occurrences is prerequisite to the forecast of an epizootic. Therefore, some of the important contributions to the history of botulism may be recapitulated.

The earliest history of botulism in waterfowl in California was an observation of the disease in 1890. Reports of the mortality from western duck disease continually increased after 1909, (Hobmaier, 1932). Clarke (1913) reported great losses in the southern San Joaquin Valley in 1913. Wetmore (1918) published accounts of occurrences in Utah in 1918. Another record death rate occurred in northern California in 1927 (Sperry, 1927). In 1930, Kalmbach and Gunderson (1934) discovered the causative organism. McLean (1946) gave an account of the outbreaks at Tulare Lake from 1938 through 1945, with the peak losses in 1941.

Reviewing the literature on the various outbreaks of western duck disease there is an indication that the epizoötics are cyclic. Peak mortalities are apparent at the beginning or end of each decade, with moderate or no losses during the intervening years. Unfortunately, the estimates are insufficient in number to allow a graphic illustration for substantiation of the cyclic theory, but there is a trend of that nature. McLean covered the early 1940's with reliable estimates of losses clearly showing a decline in the death rate to a complete disappearance of the disease beyond 1945. Subsequent investigations failed to disclose any botulism in the Tulare Lake Basin through 1951.

The last great outbreak in the San Joaquin Valley was preceded by the severe winter of 1937-38 with subsequent flooding of the Tulare Lake Basin. Milder winters followed until it appeared that California was facing a drought. In the winter of 1951-52 an excessively heavy snowfall in the Sierra Nevada mountains resulted in record snow depths. The spring thaw filled the several rivers flowing into the southern San Joaquin Valley. The Kings, Kern, Kaweah, and Tule rivers reached flood stage in the middle of June resulting in the inundation of farmlands which was increased by the Tulare Lake levees giving way.

It was recognized that over 200,000 acres would be under water when the first flights of ducks arrived in the area. The more important realization was that conditions favorable for the development of botulism had been recreated. Therefore, it was deemed essential to reconsider all possible methods of disease control and to evaluate all of them for the purpose of selecting the most applicable. The importance of these considerations was emphasized when it was noted that a highly successful 1952 breeding season predicated an increased duck population in the Pacific flyway.

PAST PRACTICES

One of the earliest recommended procedures was that of duck rescue and individual treatment. Sick birds were collected, and their individual treatment varied from enclosure in pens with fresh water to forced flushing with water, potassium permanganate solution, or mineral oil. A recently adopted procedure was the individual inocuuation of antitoxin. The birds were given daily care in the "hospital," until they either recovered or died.

Early in the history of the disease it was observed that ducks would evidence symptoms of the malady along the shallow edges of lakes or ponds and on mudflats. It was apparent that a primary corrective measure would be eradication of such edge conditions and mudflats.

With the discovery that duck disease was caused by the toxin of *Clostridium botulinum* Type C, two further remedial measures evolved. They were concerned with the production of toxin through the presence of organic matter which furnished the necessary medium for growth of the organism. The presence of vegetable organic matter in the form of grain or stalks could be considerably lessened by burning or disking the stubble—the first method being preferred in that less residual plant material remained. Animal organic matter formed by the carcasses of dead birds could be greatly reduced by collecting and burning them. Subsequent research by Hobmaier and others demonstrated the increased toxigenic capacity of the organism when cultured in animal organic media over vegetable organic matter. This work emphasized the urgency of gathering and destroying dead birds.

Further work in the research laboratories of Kalmbach, Quortrup, Sudheimer (1942), and Sperry (1947), brought out other practical field expedients that might be used to combat the disease. Creating a flow of water through the process of channeling or pumping served to aerate the environment of the obligatory anaerobes; deep water lowered the temperature below that considered optimum for the production of toxin; and dilution or removal of toxin was effected by raising or lowering the shorelines.

All of the above measures have been used for years, and they have aided in controlling the ravages of botulism.

THE 1952 SITUATION

The flooding of Tulare Lake did not allow for any preparatory work of burning or disking stubble fields. Actually, the flood submerged many fields of unharvested barley which would attract the ducks and simultaneously provide media for the organism. The vast acreage under water made it impossible to prevent the formation of mudflats and shallow edges.

Beyond the flooded area, irrigated lands about Tulare Lake amounted to approximately 40 sections. All of the ranchers agreed to cooperate by holding irrigation water on the fields a minimal period of time, allowing three days for flooding, two days as a holding period, and three days for drainage.

Weekly surveys of the Tulare Lake Basin were begun in July, 1952. A careful check of the water levels was made for the purpose of determining the speed at which the water receded, and to note just what areas would be dry, shallow, or deep at the time the waterfowl would arrive. The entire area was plotted by an aerial survey which revealed that bordering the lake there existed a checkerboard of flooded and dry fields.

In the middle of August ducks arrived in significant numbers. Field personnel were assigned to the area and began an intensive daily surveillance, which consisted of familiarization with those sections under water, estimated populations of waterfowl, and recording air and water temperatures.

The populations of ducks for the entire basin numbered about 5,000 at the beginning of August. They increased to approximately 250 000 in the middle of the month to over a million at the end of August. Ducks continued to fly into the area until the maximum population was estimated at two million birds in the middle of September.

On September first, temperatures soared to record seasonal heights. A few losses had occurred in August, but with the increased temperature the mortality became alarming. The site of the outbreak had been in grain early in the year when the main levee broke. Water was pumped out of the flooded sections as rapidly as possible by the rancher in order to reclaim his lands. At the time that botulism appeared, six square miles of flooded land remained, much of which consisted of shallow stubble fields and mud.

CONTROL PROCEDURES

Four procedures designed to keep waterfowl losses at a minimum were followed. The main course of action was herding ducks from designated danger areas. Secondarily, but of considerable importance, was the operation carried out through the cooperation of the U. S. Fish and Wildlife Service in distributing about 130 tons of feed to attract the ducks to the safe area near Firebaugh approximately 70 miles north of Tulare Lake. In conjunction with this feeding program, the cooperation of the Grasslands Association and the U. S. Bureau of Reclamation is acknowledged. These agencies made available land and the necessary water for this problem and a closely associated duck depredations problem. The other measures were removal of increased toxin sources by gathering and destroying dead birds and the prevention of toxin concentrations by methodically changing water levels of irrigated fields.

The equipment used in herding ducks consisted of rifle grenades or flares fired from army rifles provided with grenade launchers; aircraft signal flares fired from Very pistols, used with the airplane; an air-thrust boat which was assembled as a 14-foot aluminum hull with an airplane motor mounted on the rear; and a smoke-generating machine that produced a heavy fog by means of vaporizing a specially developed type of oil. All of the above supplies were furnished through the cooperation of the U. S. Fish and Wildlife Service. The State of California supplied two airplanes used in herding and survey work and all personnel needed to carry out the project.

Herding on small areas, consisting of one-half square mile or less, was done by means of rifle-grenade flares. As the birds flew off danger areas they could be moved in the desired direction by placing personnel armed with the grenades at strategic locations. This method was ineffectual on areas of one square mile or larger because of the limited number of personnel and equipment.

On areas of from one to two square miles the above procedure used in conjunction with the air-thrust boat proved effective. Directional fire and accurate timing were necessary to prevent the birds circling back into the area. Herding could also be accomplished by firing flares from an airplane together with the rifle grenade fire of men stationed about the field. However, during the latter operation safety considerations dictated supervised coordination through the use of radios and signals.

When the size of the sector exceeded two square miles it became necessary to employ both the airplane and air-thrust boat. The boat was used to raise the ducks and the plane to herd them. It was observed that short movements of birds not exceeding 300 yards was far more successful than attempts to clear a field in a continuous flight, in that circling of the ducks behind the operation was thus circumvented. One hour would suffice to rid a four-mile area of ducks. Men were stationed along the perimeter of the danger zone to fire flares and thereby prevent the return of the ducks.

CONCLUSIONS

The entire operation was successful in reducing the mortality in waterfowl considerably below that which would have occurred naturally, had not the procedures outlined above been utilized. For comparative purposes it may be pointed out that, in 1941, 250,000 ducks perished at Tulare Lake Basin out of an estimated population of two million. The losses suffered in 1952, when the above procedures were applied, were estimated at 20,000 birds from about two million ducks. In other words, the 1941 death rate at Tulare Lake Basin was 12.5 per cent, and in 1952 the loss was about one per cent.

Although herding was undoubtedly the major factor in lowering the mortality figures, water manipulation assisted in reducing the number of deaths. The entire costs of the operation slightly exceeded $10,000. Duck rescue work would have doubled the cost; and would have been effective in saving about 5,000 ducks, only about two per cent of the potential mortality. This is based on estimates that each bird rescued requires an expenditure of from three to five dollars.

Herding of ducks proved advantageous in the Tulare Lake Basin, where the principal crop is cotton, but it could not be applied in the event of botulism in the Sacramento Valley inasmuch as rice depredations present an equally serious problem.

Worthy of consideration would be a special waterfowl hunting season. This plan for biological control of disease might have some merit in that it possibly could be effected with less expenditure of funds and the conservation of ducks that otherwise would not be utilized. Regulatory personnel would be required to designate those danger areas over which the hunters could shoot. The margins of flooded lands could be kept relatively free of birds by the efforts of the hunters. As succeeding irrigated fields displayed contamination with toxin, the open areas could be shifted. Rigid control of the numbers of hunters allowed in the field, permitting only those sufficient to accomplish the purpose, would not impose a drain on the total duck population, but would in effect lessen the number of deaths occurring.

Control of disease in the wild of neecssity means treatment of the environment rather than treatment of the individual animal, herd, or flock. Economic considerations alone make the latter course impracticable. A general influence on environment may be achieved in either of two ways: changing the enviornment *per se*, or changing the environment by moving the population. These facts formed the basis upon which botulism was successfully controlled.

SUMMARY

Excessive heavy snowfall in the Sierra Nevada Mountains during the winter of 1951-52 promised flooding of the Tulare Lake Basin. Through a knowledge of past conditions, it was recognized that a threat of botulism would exist in the following summer. All past practices used in managing an outbreak of botulism were reviewed and evaluated. The most feasible control procedures were put into effect immediately upon the appearance of botulism. They included the coordinated effect of (1) herding ducks by plane, air-thrust boat, and through the use of pyrotechnics, (2) pumping operations through cooperation of the farmers in the area, and (3) the distributing of feed elsewhere. Comparative data obtained during the 1941 and the 1952 epizootics at Tulare Lake showed a reduction from a twenty per cent to a one per cent mortality. Therefore, the effectiveness of herding in coordination with other field practices for the control of botulism was proven.

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DISCUSSION

MR. GLADING: Just a word at this point. Tulare Lake is one of these historic things. When white men first came to California, it looked like just the place to start an irrigated growing of grain. They were warned by the incumbents, the Indians, at that time that it was not a good place to live because pretty soon there would be a big flood water.

Tulare Lake has had a history of being alternately dry plains, flood lakes, and finally irrigated land. There is nothing too regular about it, but when you have about three or four heavy rain years in California, in spite of man's best efforts toward flood control, Tulare Lake is going to be flooded.

This past history has given us quite an insight into future cycles, and what it is going to be in waterfowl. When everything is right for it, Tulare Lake is going to be flooded. When it is, we can say that botulism is going to be present; and when warm weather arrives, the botulism present when the ducks move in in the fall will increase.

I might say that this idea of having a special duck season at Tulare Lake was presented to the Fish and Wildlife in the planning stage, and it was decided that we had better try to handle it entirely with our own personnel. Our method this year, of course, was to have trained technicians brought in to work on recognized areas where botulism was occurring and have our men herd the ducks off. The only difference between this and what was suggested was some type of a special season in which the general public got to do the herding in designated areas. Whether that has any merit, I don't know. I tend to differ a little with the views of Rosen on this.

If there is any question, I will be glad to answer it. I happen to be on the middle of that, so that I can answer all them, or try at least.

DR. FALLIS: He has given you a real challenge, ladies and gentlemen. I think someone should take the opportunity of trying to put him on the spot.

I wonder whether there is an ideal water level above which you don't have any trouble. Years ago when I was a youngster, I think the only time we ever had occasion to see botulism in the territory of Ontario was a small outbreak, and some people sent us some information about raising the water level. Our operation was relatively small compared to the operation you carry on in California.

MR. GLADING: Sir, you have asked a very good question that people frequently ask in the face of a botulism outbreak. However, you notice the only thing I bragged about was what we did about it at Tulare Lake. We had a tremendous outbreak in the Sacramento Valley and they followed that and weren't successful in controlling it. It was so widespread and it occurred just at the time when so many clubs were getting their blinds ready for the shooting season. We had a good many inquiries from these people, and we told them if they must have water on their land—and naturally they did because they were getting ready for a duck season—they had better have it at least eight inches deep. We thought that is as good as we could do for an answer, and actually I don't think it is too good.

This year—I guess you learn something new every year on botulism—we have still got botulism. It is not nearly as bad as it was last fall, but this is an extremely mild winter from the standpoint of temperature. Ordinarily we figure that when we get our first frost in the Sacramento Valley, we figure we have our botulism pretty well under control. We congratulate ourselves. But we didn't get frost until along in February this year; so apparently botulism hung on in some fashion all winter long in the Sacramento Valley in spite of the fact that we had considerable water.

One thing that is important to remember is that ducks can get botulism on one pond and then be scared off and go elsewhere to die; so when you have a complex situation of duck clubs and surrounding agricultural land all mixed up together, you are really getting a tremendous number of ducks dying on a refuge area, whereas they might not have contracted it there at all.

To answer your question specifically, we tell them they had better have eight inches of water. We are still not too sure that is the ultimate answer.

DR. FALLIS: Anyone else have a question?

A VOICE: I was wondering if the expense of herding ducks from the Lake could not be reduced by the use of loud noises from a public address system. Would that not cut down on the cost of the operation?

MR. GLADING: I would think probably so. We tried to get hold of a siren, and I had one located. This one only costs $10,000, whereas the cost of medicating each and every duck would cost $3 to $5 a duck. We learned a lot by pooling our knowledge with that of the people in other parts of the state who had used noise-making devices. We tried to smoke them out, and it wasn't too successful, and we attempted to get hold of a siren, but we didn't have any, so we were unable to use that.

CHAIRMAN CHEATUM: I am sorry that we will have to draw this discussion to a close, unless Mr. Kalmbach might have a comment to make on this.

MR. KALMBACH: I would like to compliment the California department for anticipating the outbreak and mobilizing its resources in order to combat the outbreak in time; although I don't believe that there is too much new from the standpoint of information, it does represent a coordinated effort of several methods and was rather effective.

BOBWHITE POPULATION FLUCTUATIONS AND VITAMIN A

V. W. LEHMANN

King Ranch, Kingsville, Texas

Bobwhite (*Colinus virginianus texanus*) populations on southwestern rangelands are strikingly unstable. Densities change, virtually overnight, from relative scarcity to abundance. Abundance is promptly followed by sharp decline, with high populations seldom persisting in the same territory for more than two successive years.

Normally, winter populations present a crazy-quilt pattern of local abundance and scarcity. Less frequently, marked increases occur simultaneously over vast areas including ordinarily inadequate range to result in the spectacular overpopulations which Leopold (1937) termed "irruptions." Quail irrupted in southwestern Texas in 1923, 1930. 1935, and 1941, each time in the second of two successive years of atypically favorable rainfall.

Bobwhites were at or near peak densities on one of our study areas in August, 1949, and again in August, 1950. On that area, and throughout southwest Texas, both bobwhites and chestnut-bellied scaled quail (*Callipepla squamata castanogastris*) literally vanished in the winter of 1950-1951.

A total of 270 quail livers were collected and analyzed for Vitamin A[1] during that period of population surge and decline. Although the sampling was small, the results are suggestive when considered against the backdrop of other field data.

The area of principal study was the Canelo Pasture, 27,208 acres of brushland and semi-prairie located approximately three to nine miles west of Riviera in Kleberg County, Texas. The soil of Canelo is an integration of Victoria-Goliad and Valentine-Nueces sand. Woodv shrubs, principally mesquite (*Prosopis chilense*) and granjeno (*Celtis*

[1]In the research laboratories of the Celanese Corporation of America utilizing a method described by Gallup and Hoefer, Journal of Industrial and Engineering Chemistry, Volume 18, 1948.

pallida) dominate approximately 15,000 acres in northern and eastern Canelo and occur as scattered individuals, and small mottes over the remaining territory hereinafter termed "semi-prairie." The use of the pasture by a herd of breeding cattle is continuous. Herbaceous cover is of three general classes: "tall," "medium," and "short" grass, contingent principally on the abundance and thriftiness of tall perennial grasses such as bluestem (*Andropogon*), tanglehead (*Trachypogon*), false bluestem (*Heteropogon*), joint grass (*Elyonurus*), and prairie dropseed (*Paspalum plictatulum*).

This study would have been impossible without the interest and wholehearted cooperation of K. D. Brown, superintendent; E. F. Rogers, chief chemist; R. H. Printz and W. O. McReynolds, research chemists of the Celanese Corporation of America. Dr. R. B. Eads, principal entomologist, and B. G. Hightower, Texas State Department of Health; Dr. Asa Chandler and Dr. J. Dan Webster, The Rice Institute; J. A. Badillo, Texas A. & I. College; and Raymond L. Henry, now of Southwestern Medical College, are principally responsible for parasite data. William G. Fuller and Henry, while biologists for King Ranch, also conducted various phases of field research, especially quail census. Dr. W. P. Taylor, U. S. Fish and Wildlife Service, retired, generously provided frequent advice and assistance. The management of King Ranch; *i.e.*, R. J. Kleberg, president; R. M. Kleberg, chairman of the board; R. M. Kleberg, Jr., assistant manager; and the writer, acknowledge the contributions of the above and all other cooperators with sincere gratitude.

CLIMATE AND GENERAL CONDITIONS

The year 1949 was favorable for bobwhites. Rainfall, January through December, totaled approximately 39.52 inches or 5.16 inches above average (34.36 inches). Rainfall was also well distributed. Measurable precipitation occurred each month and was generous in April (8.16 inches) and in July (8 inches). Abundant moisture in key periods promoted early nesting and prevented usual late-summer drought. Reproduction was high and survival was good. The first collection of birds in September of 1949, therefore, was from a heavy population on above-average range.

The winter of 1949-1950 was mild; predation was insignificant, and hunting was light. Only a few showers aggregating less than one inch of moisture fell in Canelo Pasture from January through May 13, but the quail populations continued at or near saturation for the season and habitat. Rainfall was very heavy (8 to 12 inches) May 14 to June 2, producing the rankest ground cover since 1947. Reproduction was again high.

Rainfall on June 2, 1950, however, was the last really effective moisture until March 26, 1951. "Short" grass areas in Canelo parched by early July; "medium" grass areas by mid-July; and even the territory predominantly in tall perennial grasses was brown by late August.

Food for the heavy quail population was evidently becoming scarce by late July. Birds concentrated at prairie sinks (depressions usually five acres or less in size which usually provide superior feed because water collects and stands temporarily after rains) in unusually high densities. Loafing densities at sinks ranged up to 43 birds per acre! Both banding and field reconnaissance indicated appreciable shifting and moving between cover types; prairie range gradually lost birds by egress, and brushland gained.

A rain of aproximately 1.85 inches fell in the semi-prairie of Canelo, but not in heavy brushland, on September 24. Croton (*Croton engelmanii*), an important quail food, grew vigorously. "Dry northers," the offside winds of hurricanes, followed the light rain, however, and vegetation as a whole benefitted hardly at all.

Although the quail population of Canelo was sustained remarkably well through mid-October (approximately 7,745 as compared to approximately 10,787 in August) the pinch for food was apparent. Daylight hours spent "loafing" and in toilette dropped from the normal 7½ (9 a.m. to 3:30 p.m.) to about 3½ (11 a.m. to 2:30 p.m.). Persistent effort did fill crops; contents were principally goatweed and mesquite beans.

November was marked by increasing shifting and unrest. Feeding was a day-long task and birds became unusually tame. Interrupted in feeding, they usually attempted escape by running or "freezing," rather than by flight. Flight when forced, was short; feeding was promptly resumed. Hawks and other potential predators were scarce, however, and predation was light.

November concentrations built up in places where quail do not congregate in normal times; *i.e.*, on hills largely barren of all cover except goatweed, at heavily used livestock waterings where mesquite seeds in cow dung offset a natural antipathy for short cover and frequent disturbance, and alongside highway rights-of-way, even where traffic was heavy. Oats spilled by two horses at a warden camp attracted over 200 quail despite barking dogs kenneled a few feet away.

An unusually heavy freeze (approximately 22° F.) the first week in December defoliated all weeds and brush. The freeze temporarily helped quail. Goatweed, common in prairie country, thanks to the rain of September 24, shed remaining seeds; mesquite beans fell in brushy range. Much of the seed, especially that of goatweed, was immature and undersized. It was palatable. Quail in both semi-prairie and brushland gained weight in December and accepted the luxury of mid-day rest. Reprieve from catastrophe, however, was relatively short.

Foraging was again an almost continuous day-long activity by January 20. Three and one-half days of below-freezing temperatures (low 20's) accompanied by freezing rain and sleet started January 29. Coveys huddled under bushes during the entire period; they fed little, if at all. Most refused grain thrown inside the very bushes where they huddled. They almost never flushed, even when grain was thrown on their backs!

Temperature climbed above freezing on the afternoon of February 1; quail foraged incessantly and almost frantically that afternoon and the days following. Shadows of soaring vultures, ordinarily signals for "freezing" or quick retreat to woody cover, brought no response at all. Stragglers in groups of two or three, and single birds, their plumage ruffled and many too weak to fly, were common. Almost all coveys contained weak birds and some whole coveys were of that status. Another hard freeze came February 9. It was the coup-degrace.

Gradual decrease of quail from fall to winter was apparent, of course, in both semi-prairie and brushy range. In mid-February, however, quail in brushland suddenly, and within a period of about three days (February 10 to 13), became virtually none at all except on an experimental feed line, bordering unplowed agricultural land, and at some (but not all) of the windmills where cattle were fed cottonseed cake. Quail in semi-prairie did not disappear as spectacularly. By mid-March, however, quail were also rare in open country excepting along experimental feed lines, and in approximately 500 acres of still well-preserved native grassland.

Bobwhites did not "migrate" from the Santa Gertrudis Division in late winter nor were they killed on a wholesale scale by predators (Jackson, 1947). Weak birds pursued by field men frequently retreated into rodent or fur-animal burrows which are numerous in sandy country; consequently, 44 burrows (35 rodent and 9 fur animals) were excavated in early March. Twenty-four burrows (54 per cent) contained fresh quail remains—one den at least ten birds. Quail occurred as frequently in the burrows of animals neither predatory on mature quail nor "collectors" of quail remains (kangaroo rat, cotton-tailed rabbit, ground squirrel and armadillo) as elsewhere.

That the bulk of the malnourished quail had retreated into the ground to die, just as do many normal birds crippled by gunning, was quite apparent.

A shower of approximately one-third of an inch on March 18 was followed by another of 0.86 to 1.05 inches on March 24. About two and one-half inches fell March 26. Greens were conspicuous by April 8. A few pairs of quail were apparent by April 18, but most birds remained in coveys. A heavy rain (3.5 to 5.5 inches) fell in Canelo May 12. Quail then paired generally.

Clutches were about as large as normally, and hatchability was good. With ground cover consisting largely of goatweeds, and with even the goatweeds "parching" by mid-June, juvenile mortality was high. Under continued drought, Canelo Pasture, in August, 1951, had fewer birds than in any summer prior to the start of management effort in 1946.

BOBWHITE POPULATION FLUCTUATIONS

Excellent population data are available for the Canelo Pasture where direct enumerations, at least 95 per cent accurate, were made merely by driving automobiles from one clump of woody cover to another and counting the quail loafing thereunder. Quail were tabulated on sample areas aggregating from 19 to 34 per cent of the total area of Canelo each February, August, and October. Results are presented in Table 1.

It is apparent that bobwhites in Canelo fluctuated throughout the study period; quarterly losses were from about 25 per cent to about 75 per cent. Heaviest decrease, on a percentage basis, was not from August to October when breeding increase might be expected to and sometimes did exceed local habitat facilities, nor was decrease consistently heavy from fall to winter when hunting occurred (except in 1950-51), hawks were most numerous, and food and cover were at annual "lows." Rather, in both "wet" 1949 and relatively dry 1950, heaviest annual decrease was from the end of winter to breeding

TABLE 1. BOBWHITE POPULATION FLUCTUATIONS IN CANELO PASTURE

Census Period	Approximate Acres Counted	Computed Population			Per Cent Change (Period to Period)	
		Adults	Young	Total	Adults	Total Population
Feb. 1949	6,000	7,270	....	7,270	....	....
Aug. 1949	6,210	1,637	6,393	8,030	—77	+10
Oct. 1949	7,206	5,961	....	5,961	—25	....
Feb. 1950	9,304	4,281	....	4,281	—28	....
Aug. 1950	8,448	2,939	7,848	10,787	—31	+152
Oct. 1950	6,831	7,745	....	7,745	—28	....
Feb. 1951	6,071	1,750	....	1,750	—77	....
Aug. 1951	5,293	812	1,102	1,914	—54	+9

time. Even with the sub-normal carry-over of 1951, quail decrease from early spring to summer was appreciable (approximately 54 per cent).

Bobwhites are less tolerant to crowding by their own kind in breeding season than in any other period. Nesting densities exceeding a pair to 7.8 acres over areas as large as 1,000 acres have never been found on King Ranch in three successive years of intensive study. Densities of approximately a pair to 8 acres were assumed with almost slide-rule accuracy in quality cover, in 1949 (pair per 7.8 acres), 1950 (pair per 7.8 acres), and even in 1951 (pair per 7.1 acres). Quality cover (1,245 acres in 1949, 2,605 acres in 1950, and 500 acres in 1951) was limited each season, however, and was insufficient to accommodate carry-over populations. Being mobile (average movement of 51 banded birds 1.57 miles in an average span of 152 days), many quail may have sought nesting cover elsewhere, and mobility rather than mortality may have figured importantly in declines of adults from late winter to late summer or at other periods. Such was definitely not the case, however, in the winter of 1950-1951. Then mortality, possibly traceable to malnutrition, was significant.

Vitamin A levels in 263 adults and advanced juveniles are listed in Table 2.

As Beck (1943) points out, drought and heat are not conducive to the synthesis of carotenes; it was perhaps to have been anticipated, therefore, that Vitamin A stores in bobwhites would be highest (1,954 I.U.'s per gram of liver and 5,606 I.U.'s per liver) in relatively wet 1949. Despite mild weather in the winter of 1950-1951 and a spring dry, but not excessively so, average Vitamin A levels in March (1,219 I.U.'s per liver and 3,523 I.U.'s per liver) were lower than in September by about 37 per cent. Average Vitamin A levels continued to decline from March through August. On the basis of total I. U.'s per

TABLE 2. VITAMIN A LEVELS IN STUDY SPECIMENS

Collection Period	Number Specimens	I.U.'s Vitamin A per gram of liver Maximum	Minimum	Average	I.U.'s Vitamin A per liver Maximum	Minimum	Average	Per Cent Change
Sept. 1949	51	5490	112	1954	14,800	314	5606	
Mar. 1950	13	2820	453	1219	6,401	875	3523	—37
Apr.-early May 1950	10	2080	196	1013	7,904	456	2547	—28
July 1950	7	1640	49	668	4,559	144	1865	—27
Aug. 1950	28	1691	125	649	3,132	418	1549	—17
Oct. 1950	28	2580	53	749	6,527	152	1895	+18
Dec. 1950	68	2961	49	801	7,344	147	2133	+12
Jan. 1951	9	1482	28	520	3,015	69	1571	—26
Feb. 1951	9	1020	22	408	3,039	65	1024	—35
Mar. 1951	9	401	23	132	672	38	236	—77
Apr. 1951	11	1173	54	358	1,817	142	733	+211
Aug. 1951	20	2099	188	817	5,838	490	2365	+222

liver, monthly percentage drops seemingly were about 37, 28, 27, and 17. Heavy rainfall occurred in the period (May 14 to June 2). From the standpoint of average Vitamin A storage, however, its effects in improving range and feed supply were evidently offset by increased Vitamin A demands incidental to breeding (Nestler, 1946).

Increases in the Vitamin A levels of livers were registered in October (+18 per cent) and December (+12 per cent). As has previously been pointed out, food, notably goatweed seed and mesquite beans, increased in the period; Vitamin A improvement was a corollary.

Average Vitamin levels declined again in January (—26 per cent) and February (—35 per cent) under the condition of food scarce to the extent of requiring day-long foraging, and unusual cold. Die-off, spectacular in February, occurred in populations with average Vitamin A levels in the neighborhood of 400 I.U.'s per gram of liver and 1,000 I.U.'s per liver. On the basis of experiments with captive bobwhites, Nestler (1946) suggested that requirements for winter survival might be 40 I.U.'s of Vitamin A per day, although 100 I.U.'s might be necessary for real welfare and high reproduction. Severe mortality in a wild population with Vitamin A reserves at the average level of 1,000 I.U.'s per liver suggests that the daily requirements of wild birds may be decidedly higher than penned stock, especially in cold weather.

The vitamin stores of March specimens, survivors of the spectacular late February die-off, were the lowest recorded during the study. Average vitamin levels were only 132 I.U.'s per gram of liver and 236 I.U.'s for whole organs. Survival through the period of major crisis, therefore, did not mean ultimate security.

April brought spring "greens" and an awakened breeding urge; Vitamin A levels in study specimens showed average gains, as compared to March birds, of over 200 per cent. Vitamin A stores in April 1951 (average, 358 I.U.'s per gram of liver and 733 I.U.'s per liver), however, were well below April-to-early-May levels of birds on the same ranges in 1950 (1,013 I.U.'s per gram of liver and 2,547 I.U.'s per liver).

The August, 1951, collection was of birds still subsisting under drought conditions. The last general rain (about 5½ inches) had fallen May 12 and herbaceous cover after June 15 consisted largely of goatweed on bare sand. Over thousands of acres, in fact, other herbaceous plants, by actual measurement, made up less than one per cent of the total flora. Nevertheless, there had been some effective breeding and Vitamin A levels (817 I.U.'s per gram of liver and 2,365 I.U.'s per liver) were decidedly above those of April (358 I.U.'s per liver and 733 I.U.'s per liver). They were also higher, by averages of 168 I.U.'s per gram of liver and 816 I.U.'s per liver (52 per cent) than levels of August, 1950. What moisture does or does not produce in the way of food evidently counts for much more from a Vitamin standpoint than does the gross quantity of rainfall, or the length of the rainless period.

DIFFERENTIAL STORAGE

Although periodic sampling of Vitamin A levels in the whole population accurately identify the period of major mortality, additional analysis also produces interesting implications. Schultz (1948) pointed out that wide variations in Vitamin A levels were usual in birds which were members of the same covey; our data also showed marked differences between adult birds in the same groups. While the reserves of three adult birds collected from a single covey on October 17, 1950, ranged from 2,641 to 3,934 I.U.'s Vitamin A per liver, for example, a fourth adult had only 808 I.U.'s. Three adults from a covey on December 13, 1950, had reserves which ranged from 1,109 to 3,952 I.U.'s of Vitamin A per liver. Two others from that covey had levels of only 229 and 240 I.U.'s per liver, while a sixth bird had 6,000 I.U.'s.

Differences in Vitamin A levels also were appreciable in young birds, presumably brothers and sisters for the most part, collected from broods. While three juveniles collected from the same brood on August 23, 1951, had reserves of 1,125 to 1,957 I.U.'s of Vitamin A per liver, a fourth bird had only 40 I.U.'s. A fifth youngster from the group, on the other hand, had the high Vitamin A reserve of 3,210 I.U.'s.

While birds with sub-average Vitamin A reserves were common, quail with vitamin levels approximately twice average or higher also were usual. The propensity of some birds to maintain higher Vitamin A than the mean of their fellows suggests how quail as a species have been able to survive at all and invites further research in an effort to determine the causes of superiority.

Difference in Vitamin A levels in birds taken on the same ranges at identical times may be due to much more than is implied by general "hardiness." Variations in ability to manufacture and store Vitamin A, in fact, may also be influenced by sex and age.

Over the entire study period, 140 male birds averaged 916 I.U.'s of Vitamin A per gram of liver and 2,456 I.U.'s per liver while hens averaged 1,018 I.U.'s of Vitamin A per gram of liver and 2,835 I.U.'s of Vitamin A per liver.

Vitamin A levels in females were decidedly higher than those of males at the start of breeding in March, 1950 (+43 per cent) and in

April, 1951 (+37 per cent). Hens continued to average higher than males in Vitamin A through the breeding season of 1950. The average difference was 29 per cent in April-early May, 20 per cent in July. Near the end of breeding season (September 1949, and in August in 1950 and 1951) females continued to average more Vitamin A than males (+9 per cent in 1949, +15 per cent in 1950, and +14 per cent in 1951), but the difference in that period was not great.

Vitamin A levels in both sexes increased in October as compared to August 1950, but evidently not in the same degree (males 23 per cent, females 8 per cent). While the Vitamin A averages of males registered further gain in December (+10 per cent), Vitamin levels in hens evidently remained about the same as in October or actually declined (—4 per cent).

Females had appreciably lower vitamin levels than males in the hardship months of January, February, and March. With the breeding urge awakening, however, females showed higher reserves than males in April (+37 per cent).

Both Schultz and Nestler found Vitamin levels about the same in both cocks and hens taken in fall and winter from noncritical range; our September 1949 and August 1951 birds, of approximately the same status, were nearly equal. As food crisis heightened from fall through the winter of 1950-1951, however, the vitamin data suggest that hens, as a class, were less capable of maintaining Vitamin A reserves than were males. Marked differential mortality certainly occurred in the field. While the ratio of cocks to hens was approximately 1.1 to 1 in August (on the basis of 631 birds), it was 1.5:1 (on the basis of 693 birds) in March. An unbalanced sex ratio was also a widely noticed corollary of the drought of 1936. Therefore, while a differential ability to maintain Vitamin A levels is by no means established as the reason why cocks outnumbered hens following the most recent and at least one other drought crisis (1936), the implication of possible importance is strong.

Age may also count for much in the maintenance of Vitamin A reserves, at least on "hard" range. Average level of Vitamin A per liver of birds (131) over one year of age (as evidenced by solid-colored upper wing coverts) exceeded those of younger birds (127) by from 219 to 2,282 I.U.'s per liver in all except one collection period (February, 1951). Then the small size of the sample (9) and the absence of females in the juvenile collections may have produced a distorted picture.

Signs of juvenile (light weight, unkempt plumage, etc.) appeared as early as August, 1950, but the August census (4,898 birds) indicated a ratio of 2.8 young per adult. Collections plus banding, December through April, involved only 472 birds, but the ratio of young to adults was only 0.8 to 1. The possibility that mortality tracing to Vitamin A deficiency may be differential on the basis of age as well as sex, therefore, is real.

VITAMIN A AND FOOD HABITS

Two hundred craws, mostly from birds also studied for Vitamin A, provide the following general picture of quail food habits on the study areas, September, 1949, through April, 1951.

Vegetable material was approximately 83 per cent of the food eaten, and insects, 17 per cent. About 70 per cent of the vegetable material was seeds, while 13 per cent was "greens"; *i.e.,* leaves, buds and flowers.

There were 100 different plant foods (82 kinds of seeds), representing 25 families and 56 genera. As a class, what might be termed "weeds" were the most important seed producers, comprising 26 per cent of total crop contents. Seeds of woody plants ranked second on a volume basis (14 per cent), while grasses and sedges (11 per cent) and miscellaneous foods (9 per cent) ranked fourth and fifth. Only six native plants, all seed producers, made up as much as 2 per cent of total diet; they were: (1) corn field grass (*Bracchiaria ciliatissima,* 3.77 per cent), (2) sand panicum (*Panicum firmulum,* 2.97 per cent), (3) common goatweed (*Croton engelmanii,* 18.91 per cent), (4) two partridge peas (*Chamaecrista fasciculata,* 5.15 per cent, and *C. mictitans,* 2.20 per cent), and (5) mesquite (*Prosopsis chilense,* 9.37 per cent). All occurred in craws at all seasons.

Greens, 12.68 per cent of craw contents, were not segregated as to species. Present, however, were at least 16 plants of 11 families with marsh clover (*Marsilea uncinata*), chickweed (*Alsinopsis* sp.), ground spurge (*Chamaesyce nutans* and sp.), and wild carrot (*Chaerophyllum* sp.), especially prominent.

Twenty-eight different insects made up approximately 17 per cent of the diet. *Orthoptera* (grasshoppers, locusts, and crickets) occurred in 32 craws and were about 4 per cent of crop contents, but grass termites (*Isoptera*), in 34 craws, made up almost 9 per cent of the insect food. Miscellaneous feeds (9 per cent) were domestic grains (mostly hegari), grass roots, and cottonseed cake.

Segregated on a seasonal basis, Table 3, the food habits data show variations of possible significance in Vitamin A studies.

Seeds provided the bulk of diet (average 61.6 per cent) at all seasons; the evidence is strong, therefore, that southwestern bobwhites are "seed eaters" by choice. In the winter season, the critical season

TABLE 3. SEASONAL UTILIZATION OF SEEDS, GREENS, INSECTS AND MISCELLANEOUS FOODS

Kind of Food	Per Cent Stomach Contents Spring March, April May (51 craws)		Summer June, July August (39 craws)		Autumn September, October, November (27 craws)		Winter December, January, February (83 craws)		Average
Weeds	43.64		33.71		29.97		34.29		
Grasses	13.21		24.82		0.74		7.21		
Woody Plants	4.03		20.51		39.74		9.49		
Seeds		60.88		79.04		70.45		50.99	61.61
Greens		27.39		4.90		3.44		10.31	12.68
Insects		8.03		14.20		17.85		23.33	16.91
Miscellaneous		3.70		1.86		8.26		15.37	8.80
Total		100.00		100.00		100.00		100.00	100.00

in this study, seed made up only about 51 per cent of diet; by comparison, seeds consumption was 61 per cent to 79 per cent at other periods. There seems little doubt, therefore, that seeds were least numerous at the time of winter crisis and Vitamin A deficiency.

As a group, weed seeds were eaten in larger quantities (average 36 per cent) than were seeds of grasses (11 per cent) or woody plants (14 per cent). On a relative basis, consumption of weed seeds was rather constant one season to the next (30 per cent to 44 per cent). Seeds of goatweed and other weed "staples" maintained about the same relative positions in diet throughout the year; therefore, the possibilities that fluctuations in Vitamin A levels and winter deficiency traceable importantly to variations in kinds of weeds eaten or to relative consumption of weed seeds are considered rather remote.

On the other hand, utilization of grass seeds showed marked seasonal variation. An abundance of grass feed, particularly seeds of corn field grass, panicum, and bull grass, resulted from the heavy rains of mid-May, 1950; they ranked high in summer diet (25 per cent). That grass seeds were not long available, however, is evidenced by the fact that they provided less than one per cent of diet in fall. And, since quail collected in August, 1950, and feeding heavily on grass seeds (24 per cent) were relatively low in Vitamin A (average 649 I.U.'s per gram of liver and 1,549 I.U.'s per liver), the possibility that grass seeds, as a class, are relatively low in Vitamin A might well merit additional investigation. This appears especially appropriate inasmuch as the recently accelerated research and experimentation with chemical weed and brush killers poses the probability that the days of major feed production by native weeds and shrubs are numbered in many pastures.

Use of the seeds of woody plants, principally mesquite (9.4 per cent), prickly pear (1.5 per cent), tasajillo (1.2 per cent), and granjeno (1.1 per cent), also fluctuated sharply one season to the next. On a seasonal basis, tree seeds were rather insignificant in spring (4 per cent of diet), important by summer, especially late summer (21 per cent), high in autumn (39.74 per cent) but relatively scarce (9.5 per cent) by winter. Thus it is possible that the seasonal peak of mast was significant in the recorded autumnal rise in average Vitamin A levels from an average of 649 I.U.'s per gram of liver and 1,549 I.U.'s per liver in August to 749 I.U.'s per gram of liver and 1,895 I.U.'s per liver in October.

Mast production, like grass seed production, was high in 1950, but neither mast nor grass seeds ranked high in quail craws on a year-long basis. That heavy crops of grass seed and mast are less lasting than weed seeds might well receive consideration in quail range evaluation.

Consumption of greens was relatively high in winter (10.31 per cent) and in spring (27.39 per cent). It was low in summer (4.90 per cent) when Vitamin A levels also were low, but even less (3.44 per cent) in October when Vitamin A levels increased.

Thus, Vitamin A levels in study quail sometimes increased on diets low in greens, sometimes fell when greens were taken in relatively large amounts. The specific amounts and various kinds of plants segregated as "greens" in our study are undoubtedly of some importance. The average growth stage of the plant taken, however, may also be significant in regulating Vitamin A storage.

The greens which quail were consuming at the rate of about 10 per cent of total diet in winter were largely leaves of recently sprouted plants. On the other hand, the greens which made up 27 per cent of spring diet included many buds, flowers, and seeds in dough stage.

Even in non-die-off years, quail frequently use newly sprouted greens heavily in mid-winter; on diets consisting predominantly of emergent plants, droppings are watery and birds lose weight. The possibility that greens benefit appreciably only after development is advanced might also receive further investigation.

The consumption of insects rose steadily from spring (8.03 per cent) to winter (23.33 per cent). Thus, utilization was not proportional to abundance. The kinds of insects consumed varied on a seasonal basis.

While *Orthoptera* were prominent from spring through fall (3.69 per cent total feed) insects taken in winter were principally termites (*Isoptera,* 8.74 per cent total diet). Grasshoppers evidently are relatively high in Vitamin A (60 I.U.'s carotene per gram) but most insects evidently are not (Nestler, *et al.*, 1949). The possibility that termites are not only low in Vitamin A but are a starvation food in a real sense (never more than trace status in approximately 3,000 winter craws of Texas quail examined previously) is considered very real.

Further breakdown of quail-food habits suggests additional relationships between food classes, habits and Vitamin A levels. Attention is directed to Table 4. Included in this analysis are 14 fall and 21 summer craws recently analyzed, raising the number of birds under consideration from 200 to 235.

The vitamin-rich birds of September, 1949, were on a diet about 40 per cent weed seeds, 5 per cent grass seeds, 14 per cent mast, 4 per cent greens, and 26 per cent insects. There were 13 kinds of weed seeds, but common goatweed (*Croton engelmanii*) was by all odds the most important (27 per cent total diet). Corn field grass (*Brachiaria ciliatissima,* 2 per cent) was the principal grass; fruits of granjeno (*Celtis pallida,* 7 per cent) was the first-ranking shrub. Cacti fruits were relatively insignificant (—1 per cent). Insects were predominantly grasshoppers (24 per cent).

The late winter and early breeding season diet of 1950 was again predominantly weed seeds (54.5 per cent) and again predominantly common goatweed (26.4 per cent). Partridge peas (*C. procumbens, C. nictitans* and *C. fasciculata*) were relatively important (15 per cent), however, as were panic grass (*Panicum firmulum,* 5.3 per cent) and corn field grass (4 per cent). Seeds of woody plants (1.5 per cent) were insignificant, but greens (12 per cent) were appreciable and included many buds, flowers, and seeds in dough stage. Insects were evidently less than half as many as in September; they were mostly grasshoppers (8.7 per cent) and beetles (1.3 per cent).

Midsummer diet (June and July) was again importantly weed seeds (44 per cent), and 22 per cent of those seeds were goatweed. The major grasses were corn field grass (11.7 per cent), and panicum (8.9 per cent). The heavy increase in mast consumption was mainly mesquite seeds (7 per cent) and prickly pear (3 per cent). Greens

TABLE 4. FOOD HABITS OF QUAIL IN VARIOUS COLLECTION PERIODS

Kind of food	September 1949 (21 craws)	March, April, May, 1950 (34 craws)	June, July, 1950 (17 craws)	August 1950 (22 craws)	October 1950 (20 craws)	December 1, 1950 (60 craws)	January February 1951 (23 craws)	March April 1951 (17 craws)	August 1951 (21 craws)
Seeds	59	73	83	76	63	54	43	36	60
Weed Seeds	40	54.5	44	26	15	38	24	23	51
Grass Seeds	5	17.5	26	24	2	6	11	4	1
Tree, Shrubs, Cacti Seeds	14	1.5	13	26	46	10	8	9	8
Cultivated Grain and Miscellaneous	11	3.5	4	0	5	15	32	5	0
Greens	4	12	1	8	17	2	7	57	2
Insects	26	11	12	16	15	29	18	2	38
Total	100	100	100	100	100	100	100	100	100

were in trace status. Practically all summer insects (11 per cent) were grasshoppers.

August, 1950, food habits are of special interest because Vitamin A levels (average 649 I.U.'s per gram of liver and 1,549 I.U.'s per liver) were lower than in any prior period. Compared to June-July, August saw a sharp drop in consumption of weed seeds (from 44 per cent to 26 per cent). Consumption of grass seeds was practically identical (24 per cent as compared to 26 per cent); mast increased 100 per cent (from 13 per cent to 26 per cent). As in June-July, a considerable portion of the mast was prickly pear (8 per cent). Insects made up somewhat more of the food consumption than previously in 1950 (16 per cent of diet) and, for the first time, insects were not predominantly grasshoppers. Rather, termites were eaten in quantity (12 per cent). The drop in weed consumption, utilization of prickly pear in appreciable quantity, and the relatively heavy consumption of termites, taken together, suggest late-summer food shortage. Also raised is the possibility that some or all "substitute" foods were comparatively low in Vitamin A.

Quail in October registered gains in average Vitamin A levels (100 I.U.'s per gram of liver and 346 I.U.'s per liver) on a diet low in weed seeds (15 per cent), low in grass seeds (2 per cent), and about the same as in August as regards greens (17 per cent) and insects (15 per cent). Relative shortages in weed and grass seeds, however, may have been offset by heavy utilization of woody plants (46 per cent). October mast was principally mesquite (70 per cent) which, compared to prickly pear, may have superior nutritive values.

Quail also gained in Vitamin A levels in December (52 I.U.'s per gram of liver and 238 I.U.'s per liver) on a diet remarkably similar to that of the vitamin-high population of September, 1949. There was, in fact, only one broad difference; while 24 per cent of the insects in September craws were grasshoppers, 94 per cent of the insects in December craws were termites.

In January and February, 1950, just prior to and during heavy die-off, craw examinations indicated a further decrease in weed seeds (24 per cent as compared to 38 per cent of diet in December), and in other food classes excepting grass seeds (11 per cent as compared to 6 per cent), greens (7 per cent as compared to 2 per cent), and miscellaneous food (32 per cent as compared to 15 per cent). That miscellaneous food (principally hegari, oats, and cottonseed cake), purposely distributed to quail or made available incidental to livestock feeding, helped to fill the craws of some quail, therefore, is apparent. That domestic grain adequately compensated for native foods is rendered doubtful by: (1) lowered average Vitamin A levels in January and February as compared to December, and (2) large-scale die-off.

March and April, 1951, the months of lowest Vitamin A levels (256 I.U.'s per gram of liver and 509 I.U.'s per liver), found consumption of weed seeds and mast in about the same proportions as in January-February. Cold had practically eliminated insects (2 per cent as compared to 18 per cent). Greens (57 per cent) ranked higher than any other food class in any other period, and, by mid-April, much of it was buds, flowers, and soft seed, indicating the probable high Vitamin A content of this latter material.

Spring diet, 1951, compared to that of spring in the previous year, reveals interesting differences. In 1951, consumption of weed seeds was lower (23 per cent as compared to 54.5 per cent). Grass seeds also were lower (4 per cent as compared to 17.5 per cent), as were insects (2 per cent as compared to 11 per cent). Mast was more prominent (9 per cent as compared to 1.5 per cent). The most striking difference, however, was in greens which were 57 per cent in 1951 as compared to 12 per cent in 1950. Vitamin A levels were lower in 1951 as compared to 1950 and the possibility that greens in whatever category may not substitute adequately for a shortage of seeds in quail diet is established. A comparison of general diet, August, 1951, as compared to August, 1950, sheds some additional light on the problem.

Vitamin A levels in August, 1951 (817 I.U.'s per gram of liver and 2,365 I.U.'s per liver), were higher than in August, 1950 (649 I.U.'s per gram of liver and 1,549 I.U.'s per liver). The 1951 birds were evidently on a lower seed diet (60 per cent as compared to 76 per cent). Insects were proportionately higher in 1951 (38 per cent as compared to 16 per cent) and they were predominantly *Orthoptera* (comparatively vitamin-high) in both periods. The most marked contrast, 1950 to 1951, however, was in relative consumption of weed seeds. Weed seeds were 51 per cent of diet in the comparatively vitamin-secure population of August, 1951, as compared to 26 per cent in 1950, additional evidence of the value of this food class.

But how did the food pattern in winter compare to that of a "normal" winter? A series of 50 craws were collected in Canelo Pasture in December, 1934, a year when rainfall (35.89 inches) was approximately average (34.33 inches). Weed seeds were 97.24 per cent of total craw content and grass seeds 1.83 per cent. Greens were about 1 per cent; mast, insects and miscellaneous items were less than 1 per cent or trace. Another series of 50 craws collected in Kleberg County, January, 1935, contained 42.36 per cent weeds, 15.08 per cent grass seeds, 3.06 per cent mast and 39.50 per cent miscellaneous material.

Insects were trace items. Still another group of 13 craws had weeds 91.90 per cent, grasses 4.83 per cent, mast 3.27 per cent; greens and insects were trace items. Fifty additional craws collected near Canelo Pasture on January 5, 1935, contained 39.06 per cent weeds, 29.43 per cent grass seed, 2.79 per cent mast, 0.44 per cent greens, 2.97 per cent insects and 26.21 per cent miscellaneous feed. Another group of 50 bobwhites in December had eaten 3.91 per cent weed seeds, 58.46 per cent grass seeds, 36.65 per cent mast, 0.98 per cent miscellaneous material; insects and greens were trace. In comparison to the winter of 1950-51, therefore, 1934-35 craws showed higher consumption of weed seeds (+15 per cent), higher consumption of grass seeds (+19 per cent), about the same average percentage of mast (+0.7 per cent), somewhat less greens (—10 per cent), and vastly fewer insects (trace as compared to 22.33 per cent). Whether it is purposefully distributed for them, as in 1950, or not, quail in ranch land, or at least on the borders, evidently manage for considerable miscellaneous feeds, mostly domestic grains, which averaged 15.18 per cent in 1934-1935 as compared to 15.37 per cent in 1950-1951.

Still, considerable variation in the food pattern of birds in the same general area is apparent from the 1934-35 sampling. Consumption of weed seeds, for example, varied from 3.91 per cent to 97.24 per cent in study material. Wide variations in food patterns tracing to local differences in habitat may reflect in Vitamin A levels; attention is directed to Table 5, which shows differences in average Vitamin A levels of semiprairie as compared to "brush" birds, and Table 6, which shows how markedly consumption of weed seeds, mast, and insects differed in the two habitats.

Most clearly apparent is strong evidence that dense brush, from a quail standpoint, is perhaps not the everlasting reservoir of feed and the hedge against drought, overshooting, and overgrazing it is often assumed to be. Dense brush does provide some immunity from over-

TABLE 5. VITAMIN A LEVELS, SEMI-PRAIRIE AS COMPARED TO "BRUSH" BIRDS —HEAVY BRUSHLAND

	Male			Female			Both Sexes		
Period	Number Speci-mens	Average I.U.'s Per Gram Liver	Average I.U.'s Per Liver	Number Speci-mens	Average I.U.'s Per Gram Liver	Average I.U.'s Per Liver	Number Speci-mens	Average I.U.'s Per Gram Liver	Average I.U.'s Per Liver
August	9	350	991	4	732	2,115	13	467	1,337
October	11	585	1,586	10	724	1,822	21	651	1,698
December ..	8	498	1,459	10	276	680	18	374	1,026
				Semi-Prairie					
August	10	855	1,895	5	706	1,508	15	806	1,733
October	3	1,218	3,056	4	891	2,057	7	1,031	2,485
December ..	30	1,021	2,641	20	857	2,383	50	955	2,538

TABLE 6. FOOD HABITS, SEMI-PRAIRIE AS COMPARED TO "BRUSH" BIRDS, 1950

Food	August		October		December	
	Semi-Prairie 11 Quail	Brushland 10 Quail	Semi-Prairie 9 Quail	Brushland 11 Quail	Semi-Prairie 42 Quail	Brushland 18 Quail
Seeds	94.5	56.1	40.0	82.0	60.5	38.8
Weeds	43.6	6.6	33.0	Trace	51.5	6.5
Grass	46.3	Trace	Trace	4.0	8.0	1.3
Brush	4.6	49.5	7.0	78.0	1.0	31.0
Greens	Trace	Trace	16.0	18.0	2.5	2.0
Insects	5.5	2.75	33.0	Trace	16.0	59.0
Miscellaneous	Trace	16.4	11.0	0.0	21.0	Trace

grazing, and quail in brushland have cover at times when little if any exists in semi-prairie land. At times of mast peaks, there is seed food virtually unlimited. Weed and grass foods, in comparison to semi-prairie, are almost inevitably fewer in heavy brushland; at least on the basis of food production, brushland lacks continuity. The mesquite mast exhausted, food consumption shifts to insects and greens, neither of which may be Vitamin A-high and adequate in dry or cold seasons. Thus it is entirely possible that the relatively low Vitamin A levels and the sudden and nearly complete die-off of brushland quail recorded in 1950-1951 are not exclusive phenomena of "unusual" years. Food-invoked crises, in brushland, actually may be ordinary and explain why birds which so regularly "move to the woods" seldom reappear, not only in southwestern Texas but elsewhere in the state.

By now it should be apparent that the field of bobwhite nutrition is incompletely explored. Needed are analyses of principal food groups; *i.e.*, seeds as compared to greens and insects. Better still, of course, would be determinations for divisions of various groups such as the nutritive value of weed seed as compared to grass seed and mast, and newly sprouted leaves as compared to buds, flowers, and seeds in dough stage. Knowledge will hardly be exact, of course, until pro-vitamin data are available for individual plant species, and, as Nestler, Derby and DeWitt (1949) point out, these can be expected to vary on the basis of such things as soil, temperature, rainfall, and the physiology of the individual plant. Existing knowledge, therefore, poses more questions than it answers. One conclusion, however, may be reached with finality. The probability that any single food plant (such as *Lespedeza bicolor*) will transform nutritional conditions from poor to good in many places (Davidson, 1949), is much less than likely.

VITAMIN A AND BODY WEIGHT

The heaviest quail examined for Vitamin A was a hen (1949 hatch) collected July 20, 1950. It weighed 198.2 grams. Its Vitamin A reserve was low—53 I.U's per gram of liver and 273 I.U.'s per liver. The heaviest male weighed 188.9 grams; its Vitamin A reserve was 645 I.U.'s per gram of liver and 1,987 I.U.'s per liver. It also was collected in July, 1950.

The lightest mature bird, a male collected March 15, 1951, weighed only 121.9 grams. Its Vitamin A reserve was a respectable 1,000 I.U.'s per gram of liver and 2,700 I.U.'s per liver. The lightest mature hen, taken in October, 1950, weighed 132.0 grams; it had 2,580 I.U.'s Vitamin A per gram of liver and 6,527 I.U.'s per liver.

The bird with the highest Vitamin A reserve recorded in the study (5,490 I.U.'s per gram of liver and 14,800 I.U.'s per liver) was an old female taken in September, 1949. It weighed 154.5 grams. The specimen with the lowest Vitamin A reserve (23 I.U.'s per gram of liver and 28 I.U.'s per liver) was a male (young of 1950) killed March 15, 1951. It weighed a robust 159.7 grams.

Readily apparent, therefore, is the lack of positive correlation between body weight and Vitamin A reserves. By weighing a bird one definitely could not predict with accuracy that relatively heavy specimens would be high in Vitamin A and a light bird would be low.

For the best picture of possible correlations between average weight and Vitamin A levels it appears desirable to consider only old birds; *i.e.,* those with solid-colored upper wing coverts. This is because young-of-the-year weighed considerably less than old birds in late summer and fall (September 1949, minus 22.3 grams; August 1950, minus 28.3 grams; August 1951, minus 19 grams). In 1950, when a sequence of samples were collected, young (158.2 grams) did not closely approach the average weight of adults (166.1 grams) until December, when most were about six months old. The weight span seemingly spread again at the start of breeding. Old quail outweighed young of the previous year an average of 19.6 grams in March-early May, 1950, and were slightly heavier (5.1 grams) in abnormal March-April, 1951, as well.

Limiting consideration to old birds, of course, does not isolate nutrition as the principal factor in weight fluctuations. Season and sex also merit consideration. Old females were lighter than males at the end of breeding season (minus 11.3 grams in September, 1949; minus 6.6 grams in August, 1950; and minus 22.4 grams in August, 1951); evidently, hens lighter than males in late summer are a usual phenomenon (Stoddard, 1931). Weights of cocks and hens were nearly equal in winter, 1950-1951 (males 166.3 grams; females 160.5 grams), but spread again as breeding season approached. In March and April, hens weighed more than males in both 1950 (+9.9 grams) and 1951 (+9.4 grams). This phenomena has been noted in the *Grouse Report* and by Stoddard (Leopold, 1937). Still, for the entire study period, average weights of old males (78 to 162.1 grams) and old females (53 to 155.2 grams) were close together.

Highest recorded Vitamin A levels of September, 1949 (2,131 I.U.'s per gram of liver and 6,237 I.U.'s per liver) were in adults slightly below average weight (males minus 3.7 grams; females minus 7.1 grams). Birds at or near the indicated weight peak of June-July 1950 (males 167.8 grams, hens 181.9 grams) did not have the highest recorded Vitamin A reserves; rather, their levels (668 I.U.'s per gram of liver and 1,865 I.U.'s per liver) were below those of the "lighter" birds of September, 1949.

Although mature quail gained little in average weight, August to October, 1950 (males, 2 grams; females, 0), average Vitamin A reserves increased sharply (males +611 I.U.'s per gram of liver and 1,728 I.U.'s per liver; females 472 I.U.'s per gram of liver and 1,151 I.U.'s per liver). From October to December, 1950, on the other hand, average weight increased in old birds (males +11.9 grams and females +8.5 grams), but Vitamin A reserves seemingly remained about the same or actually declined (males —192 I.U.'s per gram of liver and —615 I.U.'s per liver; females —98 I.U.'s per gram of liver and —125 I.U.'s per liver). Average weights, December, 1950 (162.1 grams), and January, 1951 (162.5 grams), seemingly were about the same. Vitamin A reserves in January were evidently lower than in December, possibly by about 446 I.U.'s per gram of liver and 1,111 I.U.'s per liver.

Die-off was spectacular in February and March; quail appeared to be "lighter" (February, 150.0 grams; March, 155.6 grams), then, than at most other times. Vitamin A reserves were also low (average 408 I.U.'s per gram of liver and 1,024 I.U.'s per liver in February, 132 I.U's per gram of liver and 236 I.U.'s per liver in March). Quail foraged continuously, almost frantically, on all but the coldest days of late winter; their search was undoubtedly for food *per se* rather than for food high in Vitamin A. Added together, these things suggest that what might be termed "single starvation" was a potentially important factor in February-March die-off. Actually, to what extent were the low Vitamin A levels a symptom rather than a cause of difficulty?

The complete answer to that question will be found elsewhere than in this paper, and the study on which it is based must take measure of many essential elements other than Vitamin A. An examination of weight patterns, however, sheds some additional light on the possible significance of starvation as contrasted to Vitamin A deficiency in the

1951 emergency. Critical weight levels have been worked out for the northern bobwhite (Errington, 1931). On the premise that northern bobwhites in excellent winter condition weighed 200 grams, Errington reported that a bird weighing 160 grams (20 per cent decline) while not getting quite enough to eat, was yet in good shape. A drop in weight to 140 grams (30 per cent decrease) on the other hand, forecast serious mortality unless natural food supplies were increased. Decrease to 125 grams (37.5 per cent) was accompanied by symptoms of feebleness (weak flight, etc.) and forecast doom.

Errington's scale from 200 grams to the "nadir of wretchedness" (90 grams) is enlightening, but difficult to apply to wild southwestern bobwhites even when due allowance is made for the smaller size of the Texas sub-species. This is because wild populations, even those evidently well nourished, do not consist largely of birds at or near top weight levels. Rather, bobwhite populations, including healthy populations, describe what might be termed a weight pattern. Changes in the pattern conceivably are as important or more so than are records of simple weight decline, even in those possibly rare times when starvation proceeds at a gradual and orderly pace. After all, in any real crisis, samples consisting of live birds measure survivors rather than casualties.

Although the winter weight pattern of a quail population can and should be expected to exhibit variation from one year to next on the basis of feed, per cent of young birds in sample, etc., a composite based on 2,000 birds weighed on King Ranch and elsewhere in South Texas, 1937-1949, probably strikes close to what might be termed "average." It is presented below:

Weight Class	Per Cent Population
180-189+ grams	10 per cent
170-179.9 grams	14 per cent
160-169.9 grams	28 per cent
150-159.9 grams	34 per cent
140-149.9 grams	12 per cent
130-139.9 grams	2 per cent
120-129.9 grams	0
	100 per cent

Average weight was 162.4 grams. For about half of a population to weigh less than average, therefore, appears quite ordinary. For more than about 15 per cent of a population to weigh 12 grams or more below average, however, might be taken as valid evidence of potenial difficulty; and birds 32 grams or more below average have so deteriorated physically as to be seldom encountered. A comparison of the normal weight pattern to that of December 1950 (just prior to heavy die-off) and late January-March 1951 (the peak of die-off) is allowed by the data in Table 7.

TABLE 7. WEIGHT PATTERNS OF POPULATIONS

Weight Class (in grams)	December-January Average 2,000 birds	Per Cent Population December 1950 74 birds	Late January-March, 1951 41 birds
180-190+	10	23	0.0
170-179.9	14	39	7.3
160-169.9	28	23	27.0
150-159.9	34	12	34.0
140-149.9	12	3	7.3
130-139.9	2	0	12.2
120-129.9	0	0	12.2

The weight pattern of birds in December, 1950, shows a striking departure from "normal" in that 97 per cent of the sample of 74 birds weighed 150 grams or more. Whatever the December, 1950, diet may have lacked in Vitamin A, it certainly was rich in elements resulting in heavy weight.

The weight pattern of late January-March, however, is the opposite of encouraging. The percentage of the population in the 150+ grams class had dropped from 97 per cent in December to 68.3 per cent. What might be termed "distress" classes (under 140 grams) increased from no birds in December to about 25 per cent. If weak flight was a valid symptom, many "survivors" were none too secure.

What percentage of abnormally light-weight birds were Vitamin A deficient; what percentage of "heavy" birds were of that status? If 400 I.U.'s of Vitamin A per liver (a minimum 10-day survival level for captive birds) is arbitrarily accepted as the line dividing deficiency and adequacy (this solely for comparative purposes), 4 to 16 quail weighing less than 150 grams were Vitamin A deficient. Thus in only about 25 per cent of the small sample did it appear likely that a low vitamin reserve of 400 I.U.'s per liver was an accompaniment rather than a cause of difficulty. On the other hand, 21 of 80 birds weighing over 150 grams (21 per cent) had Vitamin A reserves of less than 400 I.U.'s per liver. Thus low winter Vitamin A reserves occurred in about as large a percentage of birds near or above average weight as in that segment weight-deficient. And, although low Vitamin A reserves may not actually have caused large-scale die-off, Vitamin A reserves at die-off time were dangerously low in as many birds "fat" as poor.

VITAMIN A AND LIVER WEIGHT

The average weight of 263 livers analyzed for Vitamin A was 2.75 grams. There was no significant difference in liver weights of juveniles (132 birds: 2.76 grams) and adults (131 birds: 2.74 grams); average liver weights of males (140 birds: 2.74 grams) and females (123 birds: 2.77 grams) were practically the same. While the average weight of 53 livers, old hens (2.81 grams) was slightly greater than that of 70 young hens (2.74 grams), the livers of 78 old roosters (2.69 grams) averaged less than those of 62 young males (2.78 grams). Sex and age, therefore, seemingly affected liver weight little if at all.

Livers were heaviest (3.13 grams) in July, 1950; the range was lush and the overall average weight of quail was greatest at that time (175.9 grams). Sample quail livers also averaged above three grams per liver; however, in January (3.552 grams) and February (3.248 grams), 1951, when body weight was not high (156.3 grams). On the other hand, March, 1951, livers were the only samples weighing under two grams (1.875 grams). The late January-February collections included four birds with atypically enlarged livers weighing 7.3, 8.3, 9.1, and 9.3 grams respectively. Two of these had low Vitamin A reserves per gram of liver (22 and 61 I.U.'s); others had 344 and 191 I.U.'s respectively.

The above plus "bleached" or cream-colored livers which occurred at various times and were frequently low in Vitamin A are receiving further study.

VITAMIN A AND REPRODUCTION

Nestler (1946) found that a deficiency of Vitamin A in the diet of breeding quail affected their survival, reproduction, and the survival of offspring. A deficiency in the growth diet affected the growth rate and the survival of chicks, and their livability during winter.

Unfortunately for this study, 15 "key" livers, *i.e.,* of females in various stages of egg production, were lost. Against the backdrop of abundant field data, however, the remaining material is suggestive.

The Start of Breeding. Stoddard (1931) reported that the actual time of pairing depended largely upon the weather and the start was coincident with the first bobwhite call notes. Actually, many and perhaps most quail select mates from within individual covey groups long before whistling is consistent or occurs at all, before warm weather is continuous or nearly so, and before pairs, as such, break away from winter groups. In 1944, for example, when quail trapping by the car-drive method was continuous winter to spring, quail in "twos," cock and a hen, split off from coveys as they were "herded" from loafing sites to trap sites as early as February 6. Loose loafing associations, with "pairs" loafing apart from main covey groups and fights resulting when pairs and covey remnants were driven together, were usual by March 10. Still, day-long field reconnaissance did not reveal the first independent pairs until March 26, and whistling was recorded two days later.

In 1950 two females containing eggs with calcified shells were collected March 13, while the first bobwhite call was heard March 24. Whistling was not vigorous until mid-May, and it was then that covey break-up, apparent since March 11, accelerated. Bobwhite whistling, therefore, is hardly coincidental with the start of pairing, but with pairing advanced to the point of separate living and covey break-up.

Time of Covey Break-up. Although diligent search is often required for their finding, it appears that independent pairs in South Texas usually appear in late March. Thus, the first pair of quail was seen on the Jones Ranch, Jim Hogg County, on March 28, 1942, and March 26 in 1943. First pairs on King Ranch were seen from March 20 to March 30 in 1946, 1948, and 1949. In 1949, the first was seen on March 11, and in 1950 two hens were collected from pairs March 13. In 1951, following the severe drought and die-off, pairs did not appear until somewhat later than usual—April 18.

Span of Covey Break-up. While covey disintegration as evidenced by the occurrence of independent pairs begins at about the same time each year, the time required for completion varies greatly.

Thus, in Jim Hogg County, 1942, when pairs appeared March 28, pairing was not complete until the last week of April. Late March was the start, and late April found most birds paired in Jim Hogg County, 1943 and 1944. Initial covey disintegration also occurred over a period of 30 to 45 days in the Canelo Pasture of King Ranch, 1946-1949.

All these years saw moisture sufficient to provide winter "greens" by early January; buds, flowers, and newly grown seeds were plentiful throughout the separation periods. It was different in 1950-1951.

Winter and spring moisture in Canelo Pasture were scanty both years. Although some drought-tolerant plants sprouted and in fact provided considerable feed for quail, the range was not truly verdant until after heavy rainfall in mid-May, May 14, 1950, and May 12, 1951. Although covey disintegration began in late March, 1950, the bulk of the quail remained paired through May 24, and remnant coveys were seen as late as June 8. In 1951, covey disintegration, apparent in mid-April, was not completed by June 20, and the continuous occurrence of "foursomes" and "sextets," always equal as to sex, make it likely that in 1951 some quail never bred at all.

The characteristics of birds already broken away from covey associations is suggestive.

Age. In 1950, three of four actively breeding hens collected from dry range prior to the May rain were old birds (young of 1948 or before). Only two of 14 non-laying hens were old birds. Fifteen of 17 hens trapped as non-breeding covey remnants on April 26 were young of 1949, while each of seven females trapped as pairs were old birds. In 1951, however, each of four young collected as pairs on April 17 were young of 1950, and there were two old quail among the seven collected from coveys April 19. The limited data available, therefore, is not convincing. The possibility that early breeding, always desultory on dry range, is principally by older birds with young of the previous year requiring comparatively verdant conditions for general breeding is a possibility that merits further study.

Breeding Development. Birds collected from independent pairs frequently were laying. When not laying, the reproductive organs, especially of females, invariably showed progress beyond the average of birds still in coveys.

Weight. Laying hens were frequently heavier than covey birds. Thus six in the spring of 1950 (March and April) weighed, on the average, 182.1 grams. Fourteen non-layers taken on the same days averaged 155.7 grams. Laying hens continued heavy through summer. Eight collected from May 1 through August averaged 184.1 grams. There were no significant weight differences until laying was imminent, however, and hens with minute ova sometimes weighed more and sometimes less than females with ova 2 to 7 millimeters in diameter.

Vitamin A. A female about to lay had the high Vitamin A reserve of 8,320 I. U.'s per liver (2,080 I.U.'s per gram of liver) when collected March 13, 1950. Five others collected from March through July had from 2,235 to 4,559 I.U.'s Vitamin A per liver and averaged 3,569 I.U.'s per liver. On the other hand, two July females apparently in the last stages of laying had the low reserves of 273 and 144 I.U.'s Vitamin A per liver. Females with ova minute frequently showed Vitamin A reserves higher than those of females with ova "pea to marble" size, and males with small testes were sometimes lower, sometimes higher, in Vitamin A than males with testes enlarged to maximum breeding size. If the enlargement of testes and ova are accurate criteria of breeding development, however, males, as a class, attain breeding conditions before hens, and breed on lower Vitamin A reserves. Thus, at the start of breeding in March, 1950, six males averaged 872 I.U.'s per gram of liver and 2,490 I.U.'s per liver. Seven hens averaged 1,517 I.U.'s per gram of liver and 4,410 I.U.'s per liver.

In April and early May, two males averaged 857 I.U.'s per gram of liver and 1,916 I.U.'s per liver, while females (eight) averaged 1,052 I.U.'s per gram of liver and 2,705 I.U.'s per liver. There was a steady decline in vitamin reserves of both sexes March through August; it was from an average reserve of 2,490 I.U.'s to 1,466 I.U.'s per liver in males, and from 4,410 I.U.'s to 1,722 I.U.'s per liver in hens. Average decline was greater in hens (61 per cent) than in cocks (41 per cent). From March through July, 1950, however, inactive males (seven) from coveys had substantially higher Vitamin A reserves (1,290 I.U.'s per gram of liver and 3,439 I.U.'s per liver) than did males (six) from pairs (673 I.U.'s per gram of liver and 1,547 I.U.'s per liver). Thus breeding demands for Vitamin A, known to be heavy in females (Nestler, 1946), may also be demanding in cock birds.

VITAMIN A AND THE TIME OF LAYING

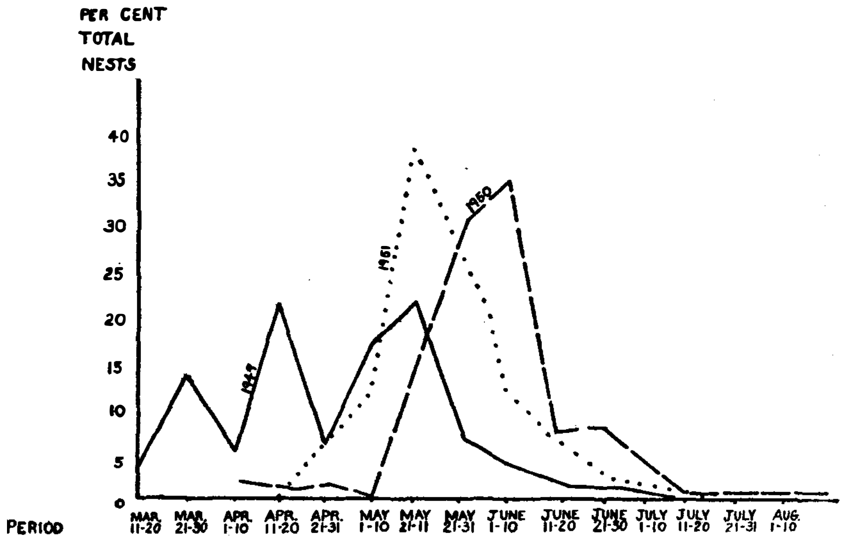
In both 1949 and 1950, field collections produced females containing eggs with calcified shells between March 11 and March 20. Average Vitamin A levels in males were 872 I.U.'s per gram of liver, and 2.490 I.U.'s per liver; reserves of females in March, 1950, were 1,517 I.U.'s per gram of liver and 4,410 I.U.'s per liver. Very probably Vitamin A reserves were at least as high in 1949 as 1950. The earliest indicated laying in 1951 was in the period April 11-20. Average Vitamin A reserves were decidedly lower in March, 1951 (males, 145 I.U.'s per gram of liver and 261 I.U.'s per liver; females 105 I.U.'s per gram of liver and 185 per liver), than in March, 1950. The possibility that the later start of laying in 1951 as compared to 1949 and 1950 may have been influenced by nutritional considerations, including Vitamin A, therefore, is considered real.

Because age, individual physiology, and similar factors may produce laying by a few quail before an appreciable segment of the population is active, the intensity of breeding is perhaps more important than the start of laying as an index of the importance of nutrition. Brood data from Canelo Pasture are considered especially valuable as indicating breeding intensity of the whole population because predators were closely controlled to promote high nesting success and intensive field work as continuous. Four hundred broods in 1949, 300 in 1950, and 100 in 1951 indicated laying intensity, as illustrated in Chart 1.

Sharp contrasts between the pattern of successful breeding in "wet" 1949 as compared to "dry" 1950 and 1951 thus are indicated.

While desultory breeding began at about the same time (mid-March), at least in both 1949 and 1950, large-scale laying was later in 1950 and 1951 than in 1949 by 50 to 60 days.

CHART I. LAYING ACTIVITY AS INDICATED BY BROODS



Cooler spring temperatures were not responsible for delay, at least not in 1950. For, while birds in the Lower Little, Arroya, and Mottas Negras pastures 10 to 15 miles north of Canelo were generally paired and laying April 20 (two of three females collected May 1 contained eggs with calcified shells), quail in Canelo were mostly coveyed until late May. Territory north of Canelo received April rains, Canelo did not.

In both 1950 and 1951, large-scale breeding did not begin in Canelo until heavy rains came in mid-May. In both years, ranges "blossomed" virtually over night. Quail layed almost immediately. Nestler's (1946) conclusion that bobwhites are physically capable of rapidly rebuilding Vitamin A reserves thus is supported, especially since the quail population which was producing full clutches in late May, 1951, was dying only about 45 days previously.

Single substantial rains (in mid-May) were followed by single marked nesting peaks in 1950 and 1951. At least in 1951, drought recurred before most young from initial layings were hatched. Periodic rains January through April, 1949, on the other hand, saw laying sustained over a period longer than in either 1950 or 1951 by about 30 days. Even in the "wet" spring of 1949, however, laying activity described several peaks (March 21-31, April 11-20, and May 11-20) with "lows" from April 1-10 and April 21-31. That wild quail require time to recoup nutritional reserves before renesting, this even on verdant range, is suggested.

That the time of rainfall counts for much is certain. A substantial rain of about two inches on June 8, 1949, did not result in appreciably increased nesting nor did substantial rains (approximately 7.5 to 10.5 inches) over the period July 3-August 7. Each rain produced some of the same food plants of spring. Neither produced all of them, possibly including those which actually counted for most.

VITAMIN A AND NESTING

Size of Clutches. Differences in pre-nesting average Vitamin A reserves in April-early May, 1950 (1,013 I.U.'s per gram of liver and 2,547 I.U.'s per liver) and April, 1951 (358 I.U.'s per gram of liver and 733 I.U.'s per liver) were not reflected in clutch size. In 1950, for example, 25 study nests beginning on or before May 31 averaged 17.9 eggs each while 25 in 1951 averaged 17 eggs each. In "wet" 1949 when Vitamin A reserves may well have been higher than in either 1950 or 1951, 42 early nests averaged 14.05 eggs each.

In both 1949 and 1950, clutch size decreased, on the average, as the breeding season progressed. Thus, in 1949, seven nests starting to incubate in July or thereafter averaged 9.7 eggs each. In 1950, average clutch size decreased as indicated below:

Number Nests	Starting Period	Average Size
25	May 31 or before	17.9
30	June 1-12	13.6
8	June 13-24	11.7
5	June 25-July 6	6.8

Gradual decrease in the size of clutches, spring to fall, was also recorded in Jim Hogg County (Lehmann, 1946). In extra-dry 1950, there was no effective late nesting.

It appears, therefore, that spring nutritional levels sufficient to allow general breeding also are sufficient to allow "full" clutches. The smaller clutches of mid-summer and early fall, however, may reflect the drain of earlier breeding effort on Vitamin A reserves, and the relative scarcity of vitamin-high greens in other than the spring portion of the breeding season.

Hatchability of Eggs. Two hundred and ninety-five of 304 eggs (95 per cent) in 21 early nests hatched successfully in 1949. In 1950, only 23 of 647 eggs (3.5 per cent) in 41 clutches failed to produce chicks. Twenty-five of 299 eggs (almost 9 per cent) in 17 nests failed to hatch in 1951. With only one unhatched egg actually infertile, and fire ants having invaded four of the five nests in which unhatched eggs were found, however, it appears that possibly lower vitamin reserves of quail in droughty 1951 did not materially reduce the hatch.

Survival of young. The experiments of Nestler and Bailey (1943) and Nestler (1946) indicated that a lack of Vitamin A for three weeks was fatal to all chicks; that the Vitamin A content of breeder's diet affected the storage of Vitamin A by the offspring; and that a deficiency in the growth diet affected growth rate and survival.

The diet of chicks is high in insects (Stoddard, 1931). As a group, insects are relatively low in Vitamin A (Nestler, Derby and DeWitt, 1949). The Vitamin A which chicks have at hatching time, as determined by the Vitamin A reserves of their parents (Nestler, 1946), therefore, may be highly important.

Two chicks about three days old from a brood in Canelo Pasture, June 24, 1950, and feeding principally on insects, had 38 and 59 I.U.'s per liver respectively. On the other hand, four young (about three weeks of age) from a brood on May 24, 1949, had the respectable Vitamin A reserves, 250 to 525 I.U.'s per liver. With new seed available in goodly supply, the juveniles used it heavily (grass seeds 72 per cent, weed seeds 26 per cent of craw content). That Vitamin A build-up in young birds may be rapid on range containing an abundance of fresh seeds is indicated.

On the other hand, Nestler found that on all levels of Vitamin A diet, breeders supplied less Vitamin A to late chicks than to early chicks. Late hatched broods with less Vitamin A at the start of life, and on "drying" range, therefore, should be doubly handicapped.

Three late-hatched (early August) young collected in October, 1950, did have low vitamin reserves (153, 295, and 333 I.U.'s per liver). Another (six weeks old) killed in August, 1951, had 14 I.U.'s per gram of liver and only 40 I.U.'s per liver.

Throughout the study, late-hatched broods were smaller than early-hatched broods. In 1949, 94 broods hatched prior to mid-June averaged 17.6 young each. Twenty-one late broods (late June, July and August) averaged only 6.64 young each. In 1950, 78 early broods averaged 14 young each; the average size of seven late broods (August) was 2.8 young each. There was practically no late nesting effort and no broods hatching after July 31 were observed in ultra-dry 1951.

In wet 1949 production to mid-summer was approximately 3.9 young per adult; net production was 2.6 young per adult in 1950. In 1951 production was only 1.3 young per adult. Predatory animals were under close control each year, and it is believed that neither predators nor weather took a heavier toll of young quail in 1951 than in 1950 and 1949. While the bulk of 1949-1950 production was hatched in a still green environment where seeds, especially grass seeds, were abundant, the 1951 crop hatched in an already dry environment of parched grass (most of which did not seed), goatweed (seed production insignificant until August) and bare sand. Both insects and tiny seeds were abnormally scarce. That high juvenile mortality (especially in the first month) of 1951 traced to nutrition including Vitamin A is held highly possible.

VITAMIN A AND BREEDING EFFORT

Concerning renesting and the breeding urge, Stoddard (1931) reported: "Bobwhites try again and again if first nesting attempts fail. Everything . . . points to the conclusion that the majority of the pairs sooner or later are successful in hatching off a brood." And, from Leopold (1937), ". . . the pair breeds and continues as a pair until the young are grown." The all-too-general concept that the bulk of quail occur as individual pairs and strive continuously to reproduce from spring through summer, therefore, is not without some basis. Insofar as southwestern bobwhites are concerned, the concept is wrong.

Almost before covey break-up is complete in spring, it is usual to find "pairs" of quail joining other pairs to form associations of adult birds. When broods are present, pairs often join broods as well. Adults collected from summer associations (which display true covey traits such as: (1) feeding together, (2) loafing in a group, (3) roosting as a body, (4) assembling after disturbance, etc.) were neither fat nor emaciated. Twenty-six males (20 from King Ranch, 1950; 6 from W. W. Jones Ranch, 1942) averaged 158.4 grams. On the other hand, 26 hens (6 from Jim Hogg County, 1942), averaging 154.3 grams, were below robust breeding weight (170-198 grams). Two males from summer groups were relatively low in Vitamin A (277 and 419 I.U.'s per liver), but the average reserve of seven (1,290 I.U.'s per gram of liver and 3,439 I.U.'s per liver) was above the average of six males from actively breeding pairs (673 I.U.'s per gram of liver and 1,547 I.U.'s per liver). The Vitamin A reserves of seven hens, on the other hand, ranged from 470 I.U.'s to 3,331 I.U.'s per liver (average 737 I.U.'s per gram of liver and 1,874 I.U.'s per liver). This was an average of 631 I.U.'s per gram of liver and 2,487 I.U.'s per liver below the average of sexually active paired females (1,368 I.U.'s per gram of liver and 4,361 I.U.'s per liver).

One thing appears certain, however; few if any birds "coveyed" in summer are actively breeding. Of 26 males, only two had gonads enlarged to maximum breeding size. Three had gonads ¾ maximum breeding size, while those of 29 were ¼ the maximum breeding size or smaller. Only two of 26 hens contained ova as large as 5 mm. in diameter or "pea" size. The ova in 24 were minute. Compatibility, after initial covey break-up, therefore, is truly a sign of "recessed" breeding.

Although time is not now available for tabulation and analysis of the summer population data at hand (from 1939 through 1951, and involving at least 50,000 quail) it is clear that only a relatively small segment of the adult population (perhaps 20 per cent or less) is in summer associations at any given time in certain years. One such season was 1943 on the W. W. Jones Ranch, Jim Hogg County; another was 1946 in the Canelo Pasture, King Ranch. Both were "wet" years with "green" range nearly continuous spring to fall.

On the other hand, it appears that more than 80 per cent of adult quail under study on the Jones Ranch, Jim Hogg County, were coveyed from June 18-July 5, 1942, and after September 9 of the same year. Independent pairs were premium in the Canelo Pasture, King Ranch, from July 20 through August 15, 1947; after July 16, 1948; after August 15, 1950; and after July 31, 1951. In every instance, "coveying" accelerated under drought conditions, and, when general break-up reoccurred, it was following rain.

The rainfall in 1942 was 2.45 inches on the night of July 1, followed by an additional 6.24 inches through July 14. On King Ranch, 1947, break-up followed a downpour of approximately 9 inches on August 12. General pairing in Canelo Pasture, in both 1950 and 1951, followed heavy rains (5½ to 12 inches) in mid-May.

In Canelo Pasture, 1948, however, 1.75 inches of rain on June 29 plus approximately 2.5 inches on July 11 were not followed by general break-up, nor did pairing follow about 3 inches of precipitation in the Laguna Larga Pasture (joining Canelo Pasture to the west) on September 9. On the other hand, a total of approximately 7.6 to 10.5 inches from July 3 through August 7, 1949, not only saw the break-up of all associations of adults but the "weaning" of most broods over six weeks old as well. After July 18, 113 of 144 broods observed in the "wet" portions of Canelo were without adults. In the "dry" southeastern part of the same pasture (which received only about 2½ inches of moisture) and the adjoining Rincon Pastures, associations and pairs with young continued about as common as before (36 of 56 broods with adults). In July and August, 1951, local showers dropping up to two inches invariably provoked whistling for a few days. They did not reactivate nesting. Neither did rainfall in saturation supply (total approximately 17 inches) beginning in Canelo September 9 and continuing with warm weather through October 31.

Thus while it appears generally true that large-scale recessed breeding is a product of drought, it is equally certain that rainfall, while alleviating, sometimes falls short of the mark. What rainfall does not produce in feeds high in ingredients which allow vigorous breeding, including Vitamin A, seems determining. Posed, therefore, are real challenges in management. For, that many southeastern ranges continuously supply the nutritional elements essential for sustained breeding under normal weather and existing use is held much less than likely. And, maximum production can hardly be obtained from adults lacking whatever is necessary to cause vigorous breeding effort.

VITAMIN A AND EXTERNAL PARASITES

Beginning in early December, 1950, external parasites appeared in unusually large numbers on some of the quail collected for study purposes. The following kinds were identified by B. G. Hightower and Dr. R. B. Eads of the State Department of Health:

Fleas (*Siphonoptera*)
1. *Echidnophaga gallinacea*

Lice (*Mallophaga*)
1. *Colinicola numidiana*
2. *Menacanthus* sp.
3. *Oxylipeurus clauatus*
4. *Goniodes ortygis*

Flies (*Diptera*)
1. *Microlynchia pusilla*

Ticks (*Acarina*)
1. *Haemaphysalis leporis-palustris*
2. *Amblyomma maculatum*

All ticks were immature forms.

In December, the nymphal rabbit tick (*Haemaphysalis leporis-palustris*) was the most numerous parasite. Of 46 quail collected in Canelo Pasture (December 13-23), 43 were infested. Seventeen quail (37 per cent) had only three to eight ticks each. Twelve (26 per cent) had from 13 to 30 ticks, however, and 14 (30 per cent) had from 65 to 123. Each of the other parasites previously listed also occurred, but the ratio of rabbit ticks to other parasites was 15:1.

External parasites continued numerous on bobwhites in January. There were 187 nymphal rabbit ticks on eight quail from semi-prairie (average 23.4 per bird); these birds also harbored 4 *Amblyomma maculatum*, 4 *Microlynchia pusilla*, 8 *Colinicola numidiana*, 3 *Mena-*

canthus sp., 12 *Oxyliperus clauatus,* and 18 *Goniodes ortygis.* Probably most important was the relative increase of stick-tight fleas. While only 16 *Echidnophaga gallinacea* were present on 63 specimens collected in December, the eight birds taken in January held 48.

February saw a marked increase of lice. While only 41 had been found on eight birds taken in January, February birds (12) had 646 as indicated in Table 8.

TABLE 8

Kind of Louse	Average Number Per Quail January (8)	February (12)	Per Cent Increase
Goniodes ortygis	2.2	21.8	891
Oxylipeurus clauatus	1.5	10.6	606
Colinicola numidiana	1.0	11.9	1,090
Menacanthus sp.	0.37	9.5	2,469

In addition, February specimens harbored stick-tight fleas (9), biting fleas (7), immature ticks (4) and rabbit tick nymphs (183).

January to February, therefore, rabbit ticks evidently decreased, on the average, from approximately 23.4 to 15.3 ticks per bobwhite. Ectoparasites as a group, however, increased from an average of about 35.5 per quail to 70.8 per quail.

Quail continued heavily parasitized in March. On nine birds, biting flies (4), lice (*Goniodes, Oxylipeurus, Colinicola* and *Menacanthus,* 103), and nymphal ticks (73) were fewer than in February. Stick-tight fleas increased, however, from an average of less than one per bird to 48 per bird. They caused real distress. One female quail, which appeared blind or nearly so when watched through field glasses, was found, upon collection, to have lost the use of one eye, possibly as a result of fleas (172) attached around the eye and on the cheek. The average number of ectoparasites on nine March specimens was 68 per quail.

Eleven April specimens indicated a vast reduction in ectoparasites. Four birds (two mated pairs) harbored a total of only 14 ticks, 4 fleas and 7 lice. Seven birds from coveys held 21 ticks, 18 fleas, 30 lice, and 2 biting flies. Ectoparasites, in April, were, on the average, about 9 per bird.

In August, 1951, external parasites on study quail were in the same status as prior to December, 1950; *i.e.,* too few to attract attention.

Heavy infestations of ectoparasites on individual quail have been found (but rarely) in 20 years of continuous field work in Texas. The 1950-1951 outbreak, however, was the only large-scale infestation ever observed. Quail were not the only species affected. Stick-tight fleas and nymphal rabbit ticks were also found on western meadowlarks, lark buntings, eastern vesper sparrow, shrike, mockingbird, roadrunner, curlew, and killdeer. They were not found on waterfowl. Adult as well as immature rabbit ticks and stick-tight fleas occurred on jackrabbits and cottontails. Baird woodrats (7) had stick-tight fleas but no ticks. Also free of rabbit ticks were white-tailed deer (2), javelina (7), coyote (1), broad-striped skunk (1), nine-banded armadillo (1), or cattle (6). Both fleas and rabbit ticks were collected from a herd of domestic goats.

Stoddard (1931) did not find quail with nymphal ticks noticeably underweight; weight was not inversely proportional to infestation in our December specimens.

When ectoparasites became conspicuous in December, no correlation between degree of infestation and weight was apparent. True enough, three "clean" birds from semi-prairie weighed from 160.9 to 183.9 grams and averaged 172 grams while the eight quail most heavily parasitized (average 108 ticks per bird) weighed only 153.3 grams. All 14 quail in the "heavily" parasitized group (65 to 135 ticks), however, averaged 160.3 grams, and one weighed 181.6 grams. Twelve "moderately" infested (13 to 30 ticks) averaged 163.9 grams, while 17 with "light" infestations (3 to 8 ticks) averaged the same weight (163.9 grams).

On the other hand, 14 "brush" birds from Mqttas Negras, with a total of only 33 ticks weighed only 157 grams, on the average. or less than any prairie birds except the eight most heavily infested (153.3 grams).

In ensuing months, average weight and degree of infestation did exhibit some degree of correlation.

Thus, when parasites increased only slightly, December (average 35 per bird) to January (35.5 per bird), average weights of study specimens also were approximately the same (December, 162.1 grams; January, 162.5 grams). A sharp increase of parasites, January (average 35.5 per bird) to February (average 70.8 per bird), was probably accompanied by a decrease in weight which was sharp in study specimens (162.5 to 150 grams). Parasites were evidently slightly fewer in March (average 68 per bird), and average weight probably increased (from 150 grams to 155.6 grams in our material). With April, birds improved in vitality and weight (average 157.2 grams), and parasites became few (average 9 per bird). That ectoparasites were more than a minor factor in weight changes, however, should not be inferred.

Numbers of ectoparasites did not reflect in Vitamin A reserves. In December, the most heavily parasitized birds (14) from semi-prairie had an average of 886 I.U.'s of Vitamin A per gram of liver and

2,188 I.U.'s of Vitamin A per liver. Quail (12) "moderately" infested (13 to 30 parasites per bird) had higher Vitamin A reserves of 1,094 I.U.'s per gram of liver and 3,163 I.U.'s per liver. Quail (17) with the fewest parasites (average 5 per bird), however, also had the lowest Vitamin A reserves of any prairie birds (546 I.U.'s per gram of liver and 1,706 I.U.'s per liver); and, "brush" birds (14), with practically no parasites (average 4 per bird), had the lowest Vitamin A reserves of all (346 I.U.'s per gram of liver and 866 I.U.'s per liver). In ensuing months, a similar lack of correlation between Vitamin A reserves and kinds and numbers of parasites was apparent.

It is considered doubtful, therefore, that ectoparasites of the kinds and in the numbers encountered created an appreciable additional drain on Vitamin A reserves. Certainly, ectoparasites did not attach in larger numbers on birds with low Vitamin A reserves. What did influence the size and composition of the unusual ectoparasite fauna of 1950-1951?

In the case of ticks, where quail ranged probably was more important than anything else. With grass sparse in semi-prairie, quail utilized existing clumps of woody cover extensively. Rabbits, both cottontails and jacks, major hosts of mature ticks, hid under those same bushes. In brushy range, on the other hand, quail and rabbits were not crowded under the same bushes; small wonder that ticks on brush quail were fewer than on prairie birds, in some instances only a mile or so away.

Weather probably was important. The close day-long huddles maintained by quail for 4½ days in late January were most favorable for the transfer of lice. The cool rains of March, perhaps adverse to nymphal ticks, possibly contributed to the reproduction of fleas.

Not to be overlooked is the fact that day-long foraging by quail did not allow normal periods for dusting and toilette.

In the winter of 1950-1951, however, many of the things which make for quail welfare—good ground cover, abundant food, quality woody cover—were no more. Beset by multiple adversity, quail became bedraggled and heavily parasitized. Under similar conditions, humans are usually heavily parasitized also.

DISEASE AND INTERNAL PARASITES

Blood smears from 75 birds trapped during and immediately after extensive die-off in early 1951, and examined for protozoans by J. A. Badille, Texas A. and I. College, were negative. Blood samples of quail (eight) and 43 of the principal wild and domestic birds and animals in Canelo and serological tests for Q fever, tularemia, and Rocky Mountain spotted fever also were negative; the determinations were by Dr. Richard B. Eads and others of the Texas State Department of Health. Worm parasites, however, were common.

In a total of 718 specimens collected in southwestern rangeland since 1942 (Hebronville and vicinity, 276 quail, April, 1942 - January, 1943; Canelo and adjoining pastures, 300 quail, 1946 - 1947; Canelo and vicinity, 142 quail, March, 1950 - August, 1951) and examined by J. Dan Webster (1944, 1948, and Webster and Addis, 1945) and Dr. Asa Chandler, The Rice Institute, Houston, and Raymond L. Henry, Southwestern Medical College, Dallas, ten different helminth worms were found. These were: *Paricterotaenia* sp., *Rhabdometra odiosa, Aulencephalus lindquisti, Syngamus trachea, Seurocyrnea* sp., *Davainea* sp., *Raillietina tetragona, R. minuta, R. klebergi,* and *Disteganius colini.* Three (*R. tetragona, R. minuta,* and *R. klebergi*) are new species; *Disteganius colini* is a new genus as well as a new species. There were six new host records, and *Disteganius colini* is the second occurrence of acanthocephalans in the Western Hemisphere in a gallinaceous bird (Webster, 1948). Cestodes not yet described include one new species of the genus *Davainea,* and several others are thought to be new. These emphasize not only the faunal distinctiveness of southwestern Texas, but also the vast amount of biological ''spadework'' important in game management still undone.

Although at least six different tapeworms were found, nematodes occurred in only 59 or about 8 per cent of the study specimens. Tapeworms were in only four of 142 birds, or about 3 per cent of the specimens taken in 1950-1951, rendering the possibility of importance in that particular population decline unlikely.

Three cestodes were found, but *Seurocyrnea* occurred in only one specimen, and gapeworms (*Syngamus trachea*) in only two. It was otherwise with the third roundworm (*Aulonocephalus lindquisti*).

Aulonocephalus was found in 241 of 270 quail (92 per cent) from Hebronville in 1942-1943, and in 265 of 300 birds (88 per cent) from King Ranch, 1946-1947. It was in 138 of 142 birds (97 per cent) collected in Canelo and nearby areas in the crisis period of 1950-1951. Incidence, therefore, was nearly universal. The degree of infestation, however, varied greatly.

The average number of *Aulonocephalus* per infested quail in 1942-1943 was 30; the average was 15 in 1946-1947. At the time of initial sampling in March, 1950, there was an average of 56 parasites in 11 specimens. Roundworm numbers apparently remained about the same from spring through summer; averages were 59 roundworms (16 specimens) in April and early May, 79 (10 specimens) in June and July, and 69 (30 specimens) in August. In the die-off period of late

January-March, however, the average number of *Aulonocephalus* in 14 specimens was 139. Average infestation in 11 quail was only 39 in April, and 52 (21 specimens) in August, 1952.

There was no significant difference in degree of infestation in adults as compared to advanced young, or in cocks as compared to females. *Aulonocephalus* built up in 1950 in a population with declining, but still respectable, Vitamin A reserves averaging more than 1,500 I.U.'s per liver. Heaviest infestations (average 141 parasites in 9 birds) was in March, 1951, when average Vitamin A reserves (236 I.U.'s per bird) were lowest, however, and marked reduction in average infestation (from 141 to 39 worms per bird) was simultaneous with vitamin improvement in April (733 I.U.'s per bird). Thus while degree of roundworm infestation was not directly proportional to Vitamin A reserves, the fact that upsurge and decline accompanied known nutritional decline and improvement may be of more than passing management significance.

DISCUSSION

High population turnover late winter to summer, summer to fall, and fall to winter were usual on our 27,208-acre study area; decrease of adult stocks was usually from about 25 per cent to about 31 per cent.

In the face of high population change, breeding numbers, effort, and success also varied. Breeding populations were approximately 1,637 birds in 1949, 2,939 in 1950, and only 812 in 1951. Yield was approximately 6,393 birds in 1949, 7,848 in 1950, and only 1,102 in 1951. Average yield was approximately 3.9 young per adult in 1949, 2.6 young per adult in 1950, and 1.3 young per adult in 1951. Compared to February populations, reproduction provided net increases of only about 10 per cent in 1949, and 9 per cent in 1951. Net gain in 1950, on the other hand, was approximately 152 per cent.

While both population loss and gain were highly variable, at least one factor in the population equation was constant; that factor was intra-specific tolerance to crowding.

In all of the habitat types under study (mesquite brushland, bulldozed brushland, tasajillo-running mesquite short brush, tall-grass semi-prairie, medium-grass semi-prairie, and short-grass semi-prairie), and despite relatively wet or dry conditions, late fall and winter densities higher than a quail to approximately two acres were only once encountered. The bird-per-acre density of tasajillo-running mesquite range in February, 1949, persisted only briefly. Breeding densities higher than a bird to approximately four acres did not occur, even in the best nesting range.

Intra-specific tensions resulted in not one, but two, well-defined "shuffles" each year. One occurred in fall, always in October, and without observable stimulus from weather or habitat decline. Another general shuffle occurred in the period between the end of winter and the start of breeding.

We attempted to hold densities higher than a bird per two acres into winter in 1950. Three typical "sinks," which provided both food and woody cover superior to that prevailing generally, were checked on July 30. At the time all offered surface water, and populations of 76, 143, and 268 birds loafed under surrounding woody cover. Beginning August 15, or well in advance of the fall shuffle, extra food in the form of hegari—as much as the birds would clean up from one day to the next—was supplied at two of the sinks, one of which still contained surface water. The third sink, having surface water and a lush growth of natural food, was considered a control.

By September 7, quail increased markedly on all areas. There were approximately 400 at the sink offering both supplementary food and surface water, 240 at the sink with supplementary food but no water, and 160 at the third sink which had water and much natural food.

Further increases were registered by September 16, when 432 quail were counted at the sink with water and supplementary food, 325 at the dry sink with supplementary food, and 241 at the control. The water hole at the control sink, however, was now dry.

The whole general territory had been improved by rain by the time of the next census October 3; quail were fewer at all of the study sinks. Decline at the pond with both supplementary water and extra food was from 432 birds to 272. The previously dry sink with extra food, and now again with water, held 140 quail as compared to the previous 325; decrease at the control was from 241 to 120. Additional decrease to 163, 62, and 18 birds occurred by October 17, and populations were only 45, 67, and 26 birds by December 17. They remained at this approximate level through February despite increasingly severe drought in surrounding territory.

Improving nesting range to carry more than a pair of birds per eight acres, likewise, may be impossible. Although the average number of satisfactory-appearing nest sites; *i.e.,* clumps of tall perennial grass at least 9 inches tall and 12 inches in diameter, was 4.0 per 100 square feet in the midsummer of 1949, 1.47 in 1950, and only 0.57 in our best nest range in 1951, nearly identical breeding densities (pair per 7.8 acres in 1949, pair per 7.8 acres in 1950, and pair per 7.1 acres in 1951) were assured with almost slide-rule accuracy. That populations would have been markedly heavier had satisfactory-appearing nest sites been more than one per 25 square feet in any nesting period, therefore, is held in great doubt.

Bobwhites as a species, it would appear, are amenable to high densities in only one period—in the time between the end of active breeding and the completion of fall moult. In fall and winter they appear to be only about one-half as tolerant of their own kind (a bird to two acres over continuous range as large as 10,000 acres) as was previously believed. In the active breeding season, a pair of quail to about eight acres may be about maximum even for areas as small as 1,000 acres. This suggests that twice as much land may be necessary to hold a peak winter population into breeding, even though the range be ideal for both wintering and nesting, a status which is far from common.

Since that part of our study area evidently capable of supporting peak nesting populations added up to only about 1,245 acres (4.6 per cent of total area) in 1949, 2,605 acres (9.5 per cent of total area) in 1950, and 500 acres (1.8 per cent of total area) in 1951, the fact that habitat played an important role in the recorded population fluctuations goes without saying.

Through the study, woody cover did not change appreciably in kind, quality, or amount. The role of woody cover in population turnover, however, was an important one.

As is indicated by the data in Table 9, the two principal brushland types; *i.e.*, bulldozed mesquite (already reverted to the extent that neither feed nor grass were different than elsewhere) and standing mesquite, did not have appreciable continuous carrying capacity. Birds were attracted to brushland in fall or winter by mast, population pressure, or grazing in semi-prairie, sometimes in appreciable numbers. Come breeding time, however, most left the brush and moved to nearby semi-prairie, apparently of their own volition. Brushland, with its frequently higher predator population and usually sparse herbaceous cover, simply did not meet the bobwhite range preferences at breeding time.

It was not that semi-prairie, as such, was satisfactory. The best-

TABLE 9. BOBWHITE POPULATIONS BY HABITAT TYPES, 1949-1950

	Quail Densities (Acres Per Quail)									
	1949			1950			1951			
Habitat Type	Feb.	July	Oct.	Feb.	July	Oct.	Feb.	July	Oct.	Average
Brushland										
Tasajillo-Mesquite	1.0	4.9	6.2	6.2	1.3	5.0	3.1	4.2	3.1	3.9
Bulldozed	3.2	23.6	10.0	10.0	16.1	12.1	50.0	52.0	29.0	22.9
Open Mesquite	9.3	29.3	13.5	12.0	10.2	6.1	52.3	48.7	36.8	24.2
Semi-Prairie										
Tall Grass	3.0	0.7	2.5	5.1	0.9	1.9	5.3	2.1	3.7	2.8
Medium Grass	6.5	6.3	2.3	3.4	1.9	1.5	22.7	8.4	4.6	6.4
Short Grass	6.5	19.6	3.6	5.7	4.7	4.6	77.8	60.0	44.0	25.2

preserved grassland[2] was more acceptable than medium- and short-grass range where tall perennial grasses (*Andropogon, Heteropogon, Trachypogon, Elyonorus tripsicoides, Paspalum plicatulum,* etc.) were less numerous and less vigorous.

Tall-grass range held the highest breeding densities, a bird per 3.9 acres in 1949, a bird per 3.9 acres in 1950, and one per 3.54 acres in 1951. Breeding densities in short grass territory averaged a quail per 22.6 acres in 1949, one per 11.9 acres in 1950, and one per 232.5 acres in 1951.

Average breeding density in tall grass for the three-year period (a bird per 3.8 acres) exceeded the average density of medium grassland (a bird per 15.5 acres) by about 308 per cent. Average breeding density of tall grass exceeded that of short grass (one per 89 acres) by about 2,242 per cent!

Tall-grass range was the most productive. Yield in tall grass as of late July - early August (and hence of the breeding season) was a brood per 14.6 acres in 1949, a brood per 14.7 acres in 1950, and a brood per 32.9 acres in 1951. Medium-grass range produced a brood per 176 acres, 29.8 acres and 111.6 acres, and short grass a brood per 163 acres, 98 acres, and 465 acres in those same years.

For the three-year study period, year-long capacity of semi-prairie was a bird per 2.8 acres in tall grass, a bird per 6.4 acres in medium grass, and a bird per 25.2 acres in short grass. Average annual carrying capacity was a bird per 3.9 acres in tasajillo-running mesquite, a bird per 22.9 acres in bulldozed mesquite, and a bird per 24.2 acres in standing tall brush. Not to be overlooked is the fact that average populations of brushland and short-grass prairie might have been even lower had they not annually received surplus production from tall grass through ingress.

The superior carrying capacity and productivity of tall-grass country stemmed from many things. Attractive nest sites were consistently more numerous. Average number, per 100 square foot quadrat, was four i ntall, only 0.25 in medium, and 0.1 in short grass near the peak of breeding on July 15. While the average per quadrat was 1.47 in tall grass on June 13, 1950, there was an average of only 0.8 nest sites in medium-grass and 0.2 in short-grass country. Under the pressure of continuous use in prolonged drought, nest sites in late June, 1951, averaged only 0.57 in "tall" grass and 0.03 in "medium" grass range. They were none at all in "short" grass country.

Sheer numbers of nest sites not only allowed for wide selection and minimum crowding, they promoted uniformity which almost certainly

[2]Tall perennial grasses usually made up 60 to 75 per cent of total flora in "tall" grass territory, and 50 per cent or less of the total flora in "medium" and "short" grass territory.

promoted safety. In 1950, for example, 50 "dummy" quail nests (nest bowls hollowed out to the approximate dimensions of actual quail nests and containing four quail eggs per nest) located in lone clumps or small "islands" of tall grass 1/20 to one acre in size experienced a predation loss of 72 per cent in two weeks. In uniform tall grass adjoining, predation loss was only 42 per cent in 50 nests in the same period. Much of that loss was encountered by nests (11 of 13 destroyed) located 30 yards or less from ranch roads which evidently served also as predator thoroughfares.

That the superior protectiveness of uniform tall cover suggested by the dummy nests was real is further substantiated by ratios of successful to unsuccessful pairs of quail in Canelo Pasture as of June 22 - July 10, 1949. While more than half of the pairs in tall-grass range had already produced broods (ratio of pairs with young to pairs without young, 1:0.76), only one pair in five had broods in medium-grass country and one pair in nine in short-grass range.

Territory with a flora predominantly tall perennial grass produced the greatest volume of vegetation from every rain or rainy period (Chart 2). Despite the fact that cattle in the pasture concentrated on

CHART 2, VARIATIONS IN VOLUME (CLIPPED WEIGHT) OF GROUND COVER PER 100 SQ. FT.

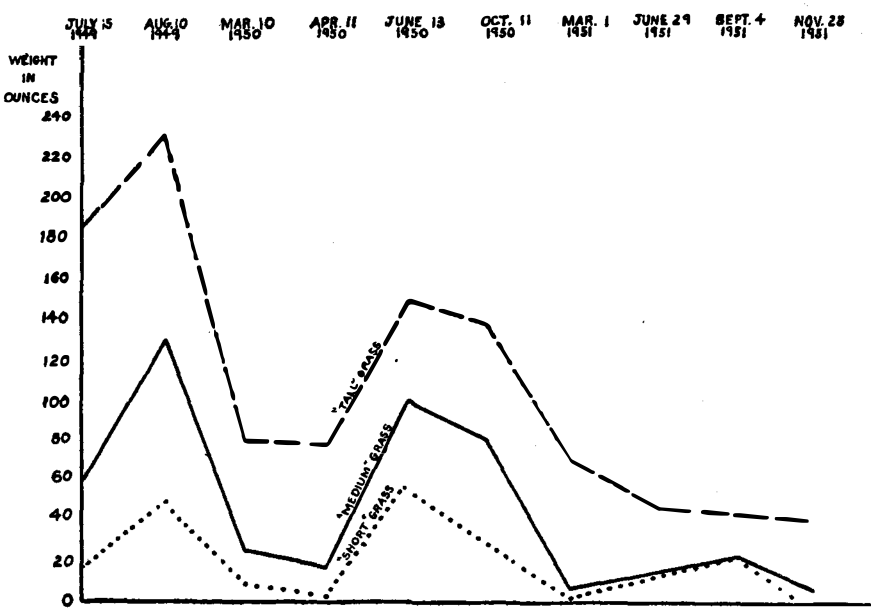
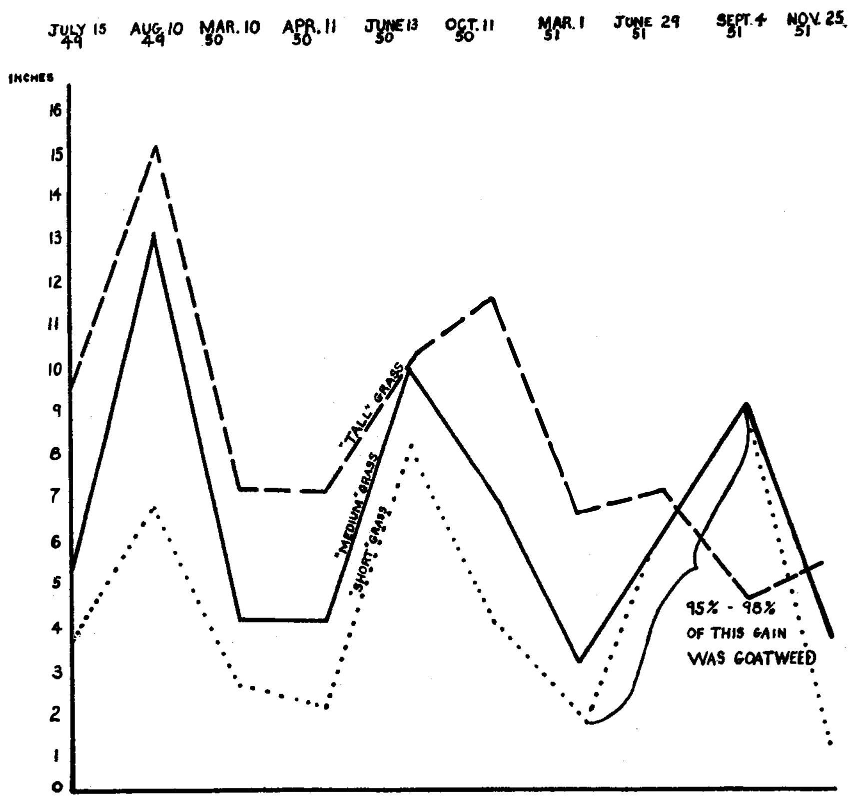


CHART 3, VARIATIONS IN AVERAGE HEIGHT OF GROUND COVER



the tall perennial grasses in prolonged drought, the average height of tall grasses did not fall below seven inches until June, 1951 (Chart 3). Thus, the tall perennial grass type provided superior protection through all natural "collapse" periods induced by frost and drought. In the medium- and short-grass prairie types where tall perennial grasses are less numerous and vigorous, ground cover declined to minimal levels (average height three inches or less; volume less than 20 ounces) at least three times in three years.

Sheer volume in cover counts for much, of course, in roosting, feeding, and escape. It counts for much, also, in protection from strong winds, especially in winter. When strong winds blow, quail generally loafed, not under woody cover, but in grass. Birds in territory which lacked grass often accept what was perhaps the best available substitute: the entrances to the dens of predators. Some never emerged.

Superiority of tall-grass range in quail nutrition, however, may be especially significant.

Principal tall perennial bunch grasses in the study territory, with the exception of the *Paspalums,* were not important food producers. Their presence, and the usage which enabled them to survive, did contribute to a continuous food supply.

The variety of the flora of tall-grass country was superior to that of semi-prairie. Sixty-seven different plants including all of the species on which quail made rapid spring gains in Vitamin A reserves were collected in tall-grass territory. Food plants included many of the legumes (*Galactia canescens,* and *G. americana, Astragalus, Vicia, Indigofera leptosepala, Hamosa, Delicholus americana* and *D. minimus, Rhynchosia americana, Petalostemon,* and *Dalea*) and were fairly common only in association with tall perennial grass. On the other hand, a total of only 57 herbaceous species were collected from medium and short grass range where heavy seed production was principally a phenomenon of late summer and fall. Thus, while tall grass country never showed the heavy croton overstories of less well-turfed rangeland, and perhaps is incapable of producing the gross seed tonnage of weedy range under favorable rainfall, food production in tall grass was definitely superior in spring and early summer and more varied, and probably more dependable most other times.

Quail survival through the crisis winter of 1950-1951 showed that food reserves hinge on much more than gross production. Compared to tall-grass prairie, fall seed production in brushland (by mesquite) and in short-grass prairie (by goatweed) were huge. Seed in both latter areas fell on ground barren or nearly so; it attracted hosts of mourning doves, lark buntings, meadowlarks, cowbirds, and other competitors. Long after the heavy combined pressure of seed eaters had largely removed the seed from naked land, quail in tall grass were still finding seed, including goatweed. Many of the seeds, upon examination, appeared to be of pre-1950 vintage. Protected from quick dissipation by once tall grass and plant debris (Stoddard, 1932), livestock grazing in the continuing drought provided automatic rationing.

Undoubtedly important from a forage standpoint, however, was the marked superiority of tall-grass territory in holding moisture. After every rain at all significant, the flora of tall-grass country "greened out" more rapidly than did that of other areas. Tall grass country remained green long after other territory parched. In 1949, for example, with only a trace of rain in May, short-grass territory was "brown" and medium-grass had "yellowed" by May 25. Tall-grass country, on the other hand, was still a verdant green. Despite generous July-August rains in 1949, medium grass range in west-central Canelo was scorched August 22, and short-grass range by August 10. The vigorous tall perennial grass territory remained green until late September. In 1951, only the tall-grass country held a tinge of green as late as June 20.

For all practical purposes, therefore, semi-prairie with a flora predominantly tall perennial grasses was less xeric than other types. This attribute not only promoted more varied and sustained seed production but maximum unit production as well. Insect production too was affected. Grasshoppers, locusts, and leaf-hoppers, and especially their highly palatable young, continued available in green range long after decline had occurred in parched territory.

In a real sense, therefore, tall perennial grasses may be considered the basic essential without which there can hardly be significant sustained quail production on southwestern rangeland regardless of whatever else may be done. Not to be overlooked in management, however, is the fact that birds once died in tall-grass territory during our studies, and something was sometimes insufficient to sustain breeding effort, even where nesting cover was good.

In the die-off of 1950-1951, the role of parasites may have been more important than might at first appear. The stick-tight fleas and nymphal rabbit ticks, so atypically numerous at crisis time, were feeding on quail blood; roundworms, principally *Aulonocephalus lindquisti,* from 4½ to 9 times as numerous as in other years, were taking body nutrients needed for survival. Parasites, however, were hardly responsible for desultory breeding at any time.

Die-off, desultory breeding (and perhaps heavy parasitism), evidently traced most importantly to the same thing—inadequate nutrition. In each breeding period, and even at die-off time in the winter of 1950-1951, quail with full crops were collected, to be sure. That vital food elements were minimal, however, can hardly be doubted.

At die-off time, the quail population at large was deteriorated physically as evidenced by such things as an abnormal weight pattern, ruffled and unkempt plumage, reduced alertness, weak flight, and abnormally high parasite infestation. Mucous discharges from nasal openings resulting from Rhinitis were very common; congealed discharge plus dust frequently clogged one and sometimes both nasal passages, but diphtheric patches were never found in throats or lungs. Some birds had watery eyes, and one had temporarily lost the use of an eye, but whether from common cold, nutritional deficiency, or because of stick-tight fleas surrounding the eye, we could not determine. Bile sacs were frequently enlarged, as sometimes were livers proper. Some kidneys appeared abnormally pale, but we were never satisfied that any ureters were completely blocked. Most of our collections were by shooting, however, and physical damage was sometimes severe.

Comprehensive tests for Q fever or Rocky Mountain spotted fever by the Texas State Department of Health were negative. Quail, at winter die-off time, were very low in average Vitamin A reserves (average 236 I. U.'s per liver). That essential nutritive elements which were premium at die-off time included Vitamin A, is held very likely.

What then, the relation of Vitamin A reserves to desultory breeding, a far more common population factor? Although our 1949-1950 collections associated high Vitamin A reserves with successful breeding and relatively low reserves with low yield in 1951, the possibility that Vitamin A levels may importantly affect reproduction is suggested but not proven. The hypothesis that Vitamin A may be very important in the breeding of wild birds was strengthened, however, in 1952. With the bulk of the population paired on range temporarily relieved from the drought by heavy rains of the previous September, and with some females containing full-sized eggs, prospects for appreciable early yield were encouraging. Persistent day-long effort in the best-grassed and most-populated range from mid-May through June produced only nine active nests; early hatched young, as revealed by August census, were practically none at all. Analysis of the livers of 16 birds collected April 23 and 24 strongly indicated a possible reason why—Vitamin A reserves in April, 1952, averaged only 114 I.U.'s per gram of liver and 269 I.U.'s per liver; reserves of seven females varied from only 107 I.U.'s per liver to 723 I.U.'s per liver and averaged only 339 I.U.'s of Vitamin A.

Even on semi-arid rangeland where rainfall is of tremendous overall importance in regulating quail environment and quail welfare, it is obvious that opportunities for advancement in bobwhite management occur. Earlier open seasons on quail shooting with yield based not only on early-fall carrying capacity, but also on the apparently much smaller spring capacity would reward proper land usage and reduce quail wastage which now is sometimes immense. Opportunities for habitat improvement are large, with tall perennial grass semi-prairie the single type with highest natural carrying capacity at all seasons imperative on all areas where high sustained quail populations are desired. Where nesting cover is adequate for substantial breeding populations, there is nothing in our experience to suggest that control of important nest predators, especially coyotes and skunks in South

Texas, does not help quail to make the most of presently limited breeding opportunities.

Aditional research beginning with the habits of the quail itself appears most desirable. It was not until August, 1951, for example, when three active quail nests located one-half mile or less from a water hole hatched every egg successfully, this despite severe drought, that we realized the possible significance of surface water in promoting yield. These particular females in question daily flew to a nearby water hole and bathed for periods of from seven to ten minutes prior to afternoon feeding; moisture important to hatching was almost certainly carried back to nests on their plumage. Bobwhites also drink surface water readily if it is available when watery foods are premium and congregate at available water in dry times. On September 18, 1951, we counted a total of 468 birds drinking at a single waterhole between the hours of 7 a.m. and 9 a.m.

Mid-summer weaning of young about six weeks of age or older and the reoccurrence of adults as pairs which are potential re-nesters occurs to a noticeable degree in all normal years on southwestern rangeland; weaning may be general when rainfall is atypically heavy. Thus, in part of Canelo Pasture which had lush cover resulting from 7.6 to 10.5 inches of rainfall recived over the period July 3-August 7, 1949, a spot check in late July showed 113 broods without adults to only 31 with adults.

That portion of the pasture which had received much lighter rainfall, and hence was not verdant, showed only 20 broods without adults to 36 with parent birds. It must be remembered, however, that it probably is not rainfall, but what rainfall produces, that regulates the breeding urge and holds the possibility of not only one brood of young from most pairs, but two broods in a single season from some.

In our present state of knowledge, therefore, additional research in Vitamin A and other nutritive essentials should probably assume high precedence. We hardly feel that bolstering the gross volume of food for bobwhites would in itself produce returns commensurate with expenditures on many southwestern ranges. We cannot, however, but wonder what catalyst enables some birds to survive on the same range while others die, and some to nest while others are quiescent. Phosphorus deficiency in cattle was found in the area of our study; its correction has resulted in lower livestock mortality and higher yield (Tash and Jones, 1947). Until the possibility that occasional shortages of Vitamin A and other elements in quail limit bobwhite survival and reproduction, few quail managers in southwestern Texas may feel entirely equal to their task.

SUMMARY AND CONCLUSIONS

In this paper the results of analysis of 270 quail livers for Vitamin A are considered against a background of field data on population fluctuations, breeding, food habits, parasites, cover, and intra-specific tolerance on southwestern rangeland.

The study period (1949-1951) included both "normal" times and the unusually cold winter of 1950-1951 which followed a "dry" summer and fall. Winter mortality was heavy, and Vitamin A reserves in the time of crisis were lower (average 132 I.U.'s per gram of liver and 236 I.U.'s per liver) than at any other time.

Averages of Vitamin A reserves per gram of liver and per liver seemingly identified periods of greatest abundance (as September, 1949) and scarcity (March, 1951). The Vitamin A reserves of individual birds, however, showed a wide range of variation at all seasons.

Under adverse conditions, the ability to manufacture and store Vitamin A may be influenced by sex and age. As crisis approached in 1950, old males, old females, and young-of-the-year appeared able to maintain Vitamin A reserves, and life itself, in the order named.

Fluctuations in average Vitamin A reserves, one collection period to the next, were sometimes coincidental with changes in diet. Rises in average Vitamin A levels were recorded with increased consumption of weed seeds or mast. Reductions in Vitamin A levels were sometimes concurrent with high consumption of grass seed, prickly pear fruit, and insects (principally termites). Marked Vitamin A improvement on diets importantly "greens" ocurred only after the material was largely buds, flowers, and dough-stage seeds as contrasted to emergent sprouts and leaves.

There was not a significant correlation between body weight and Vitamin A reserves. At the time of winter die-off, low Vitamin A reserves (40 I.U.'s or less per liver) occurred in 21 per cent of the study specimens weighing over 150 grams and in 25 per cent of the quail weighing less than 150 grams. Symptoms of distress, *i.e.*, ruffled plumage, rhinitis, decreased alertness, weak flight, heavy parasite infestations, etc., were not confined to birds of light weight.

It did not appear that high Vitamin A reserves were necessary for awakening the breeding urge. General breeding effort, however, was definitely associated with lush range and its frequent accompaniment of above-average feed. Quail, especially females, quickly attained high Vitamin A reserves after generous rainfall, and most successful breeding occurred after heavy May rains in both 1949 and 1950. With verdant range of short duration in 1951, survival of young was only 1.3

per adult as compared to 2.6 per adult in 1950, and 3.9 per adult in 1949.

High populations and stability, however, hinge on many things. Over extensive areas of 5,000 acres or so, the bobwhite's tolerance of its own kind seemingly precludes densities higher than a bird to about two acres in late fall and winter, and a bird to about four acres at nesting time. Semi-prairie with a flora importantly tall grass was the only range type under study which had marked year-long carrying capacity (a bird per 2.8 acres) and appeared to be the basic type without which quail management had no significant potentials. Surface water may hold greater possibilities for development than was previously suspected, and, because pairs of quail already successful in rearing young to the age of six weeks sometimes "wean" them to reoccur as individual pairs, two broods of young from a single pair in the same breeding season may not be altogether impossible. Until there is greater knowledge of quail habits and requirements, especially in the field of nutrition, in fact, there can hardly be successful management on a sustained basis.

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DISCUSSION

DR. FALLIS: I think you will agree that there are several different branches of research in wildlife, but two of the very fundamental ones to deal with are nutrition and disease. What do our animals eat, and what is the nutritional value of what they eat? Mr. Lehmann has opened up a very extensive problem and has done so very well in a short time because I know his report is a very extensive one. It seems to me, Mr. Lehmann, that this is an extremely interesting and important piece of research and one that should be encouraged. If sometime you can come back and tell us the Vitamin A content of the different breeds in different areas and at different times of the year, that would be most interesting. I also wonder whether it would be possible to carry out experimental studies with captured birds, giving known amounts of Vitamin A and approaching it from that angle, alongside your field studies. Would you care to comment on whether you think it is feasible to carry out such experimental studies?

MR. LEHMANN: That is the purpose of the meeting that was just held, and the naming of Dr. Dale as president. All of us in our various places are to attack certain aspects of this highly important problem, and the purpose is to get more exhaustive knowledge, evaluate it, and find out the means and places in which we individually can better serve.

CHAIRMAN CHEATUM: Dr. Lehmann has commented on his paper here, and I think very appropriately. I just want to second those comments on the necessity of pooling our knowledge and pulling together with the determination of men who can really see when information is important and what it means and where we can go from here in order to put into practice, in actual management, the improvements so discovered and worked out.

CHEMICAL CHARACTERISTICS OF NATURAL LICKS USED BY BIG GAME ANIMALS IN WESTERN MONTANA

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INTRODUCTION

For many years certain soil deposits and springs have been utilized as natural licking sites by ruminants in many areas of the world. In the mountainous areas of North America, these natural licks occur on most big-game ranges. In spite of the abundance and distribution of these licks and their extensive use by ruminants, their exact function in the biology of big game has never been satisfactorily determined.

Concentrations of animals in lick vicinities have resulted in over-utilization of forage species in some of these areas and may possibly be a factor increasing predation, parasitism and disease of big game animals. If big-game biologists could counteract the attracting power of these natural licks through a more thorough understanding of their specific use, then it should be possible to develop salting programs into more valuable management tools; particularly with reference to attaining more desirable distribution of big game on critical ranges. Accordingly, the research was designed to determine the following: (1) The mineral or minerals preferred by big game animals in various areas of western Montana; (2) the chemical composition and properties of various natural licks.

A study of the literature pertaining to natural licks revealed that workers had advanced numerous hypotheses concerning natural lick use by big game animals.

Seton (1927) quotes John Bartman who wrote on July 14, 1743, concerning natural licks in northeastern United States "... the soil, I suppose contains some saline particles agreeable to the deer who come many miles to one of these places."

Chapline and Talbot (1926) implied that natural lick materials were consumed by domestic stock and wild game for its sodium chloride content.

[1]The Montana State Fish and Game Department, Montana State University, the U. S Fish and Wildlife Service, and the Wildlife Management Institute cooperating.

Rush (1932) presented the chemical analyses of water samples from four natural licks but made no interpretation of the results. Sodium and bicarbonate ions were present in the greatest concentration in all four licks.

Dixon (1939) suggested that calcium phosphate was the mineral desired in a natural lick in Mt. McKinley Park, Alaska, and that sodium chloride was the important mineral in two licks from California.

Honess and Frost (1942) presented the analyses of five natural licks and concluded that phosphorus was probably the attracting element, but sodium chloride may have been the desired mineral in one.

Packard (1946) suggests that the concentration of mineral salts in natural licks is the attraction that induces bighorn sheep (*Ovis canadensis*) to frequent these places.

Cowan and Brink (1949) came to the conclusion that sodium chloride was not necessarily the attracting element and that phosphorus was not the essential element in the licks which they studied. They also suggested that trace elements might be the critical constituents of these licks.

McDowell and Stockstad (1952) in presenting results of mineral cafeterias and soil impregnation tests showed that big game animals in a natural lick area of western Montana preferred compounds containing sodium ions.

METHODS AND MATERIALS

Mineral cafeterias. Richter (1937) in experiments with laboratory rats, demonstrated the ability of these animals to select a diet which is conducive to normal growth and reproduction. Following this lead, mineral cafeterias and soil impregnation tests were established in various areas of western Montana on the asumption that selective use by big game animals would indicate what specific mineral was deficient or desired in their diet.

The study areas were selected because of their reputation as big game ranges, for their possession of well-known natural licks and for the particular species of big game animals using these licks. These animals included the mountain goat (*Oreamnos americanus missoulae*), the elk (*Cervus canadensis nelsoni*), the mule deer (*Odocoileus hemionus hemionus*) and the white-tailed deer (*Odocoileus virginianus ochrourus*).

A mineral cafeteria consisted of a rack holding clay flower pots containing mixtures of chemical compounds and non-lick soil secured outside the immediate lick area (Figure 1). The compounds used were water-soluble and contained elements known to be essential in animal nutrition. All compounds were used in the amounts necessary

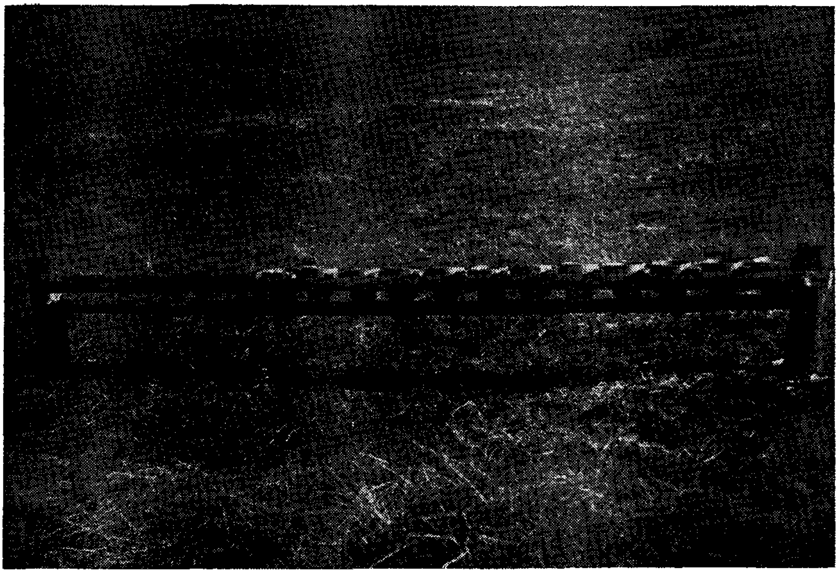

Figure 1. Mineral cafeteria used in mineral preference studies.

to make the number of ions of these essential elements equal to the number of sodium ions in five grams of sodium chloride. In order to insure a uniform mixture, each compound was dissolved in a pint of water prior to mixing with the soil. Each mixture was weighed to the nearest one-tenth pound upon placement and at frequent intervals thereafter to determine the extent of use on each mixture. A jar of soil served as a control in each cafeteria.

Soil impregnation tests. A soil impregnation test consisted of treating each of numerous square-foot soil surfaces with one quart of water containing a chemical compound. These surface areas were spaced three feet apart in a grid pattern (Figure 2) and selected at random for treatment with the various chemical compounds. Each compound was repeated from three to five times in each grid. The type and amount of compounds used for treatment were the same as in the mineral cafeterias. Use of the various compounds was determined by calculating the volume and weight of treated soil removed by the animals. In these calculations, the weight of a cubic foot of all soil types was assumed to be 100 pounds (Merriman and Wiggin, 1948).

Chemical analyses. Chemical analyses of various properties and elements were made on one set of six samples from each of 18 natural lick areas. Three of these six samples were taken from actively used portions of each lick and three from the first foot of a normal soil profile near the lick area. The samples secured from the normal soil profile will hereafter be referred to as "non-lick" samples and the area from which they were taken as a "non-lick" area. Similarly, the samples from the actively used portions of each lick will be referred to as "lick samples" and the area of sampling as a "lick area." This method of sampling was selected to facilitate comparison of "lick" and "non-lick" samples.

All soil samples were extracted with either ammonium acetate or sodium acetate, and all spring lick samples were analyzed as water extracts. Duplicate portions of all samples were analyzed as a check against human and mechanical errors.

The amount of each element available to the animals using the licks was approximated by using buffered extracting solutions with pH values similar to those found in a ruminating animal's abomasum and intestines. A series of pH determinations on the digestive tracts of 30 elk and 42 deer indicated that pH values of 4.00 and 7.00 should be used.

Phosphorus and iron concentrations were determined by extracting each sample with a sodium acetate solution at pH levels of 4.00 and 7.00 and applying the colorimetric methods of Bray and Kurtz (1945) for adsorbed phosphorus and Morgan (1941) for available iron.

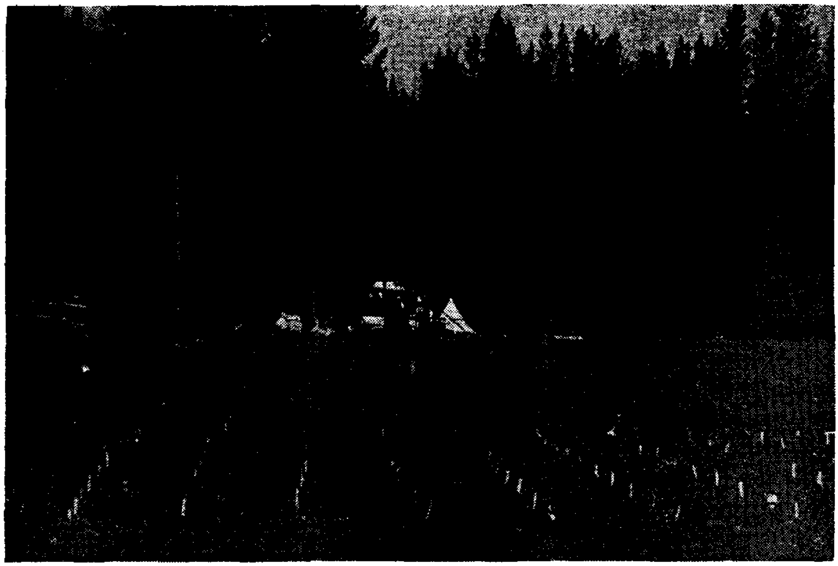

FIGURE 2. SOIL IMPREGNATION TESTS USED IN MINERAL PREFERENCE STUDIES. THE WOODEN STAKES MARKING TREATED AREAS WERE DRIVEN FLUSH WITH THE GROUND SURFACE AFTER TREATMENT OF THE AREAS WAS COMPLETED

The degree of solubility of sulphur and chlorine at various pH levels is fairly constant; therefore concentrations of these elements were determined only at a pH of 7.00. Concentrations of sulphur were determined using the method described by Morgan (1941). The titrimetric method described by Magistad (1945) was used for the chloride determinations.

The exchangeable sodium, potassium, magnesium, and calcium ions were extracted with an ammonium acetate solution at a pH of 7.00 and were determined by the spectrophotometric method of Fields (1951).

Concentrations of iodine, copper, and cobalt have not been determined to date, but analyses will be completed as time and funds permit.

pH values for all samples were determined on a water extract of each sample using a Beckman electric pH meter.

The electrical conductivity of each sample was determined using the method described by Merkle and Dunkle (1944). The values obtained do not necessarily represent the total amount of salts present because the ionization factor of each salt was not taken into consideration. These values represent only the parts per million of sodium chloride necessary in a solution to give a similar conductivity reading. However, these values do serve as a means of comparison of the lick and non-lick samples.

TABLE 1. COMPARATIVE USE BY BIG GAME ANIMALS OF MIXTURES OFFERED IN SIXTEEN MINERAL CAFETERIAS IN WESTERN MONTANA FOR A TWO YEAR PERIOD (1951-52)

Compounds used in the cafeteria mixtures	Number of cafeterias in which mixture was offered	Number of cafeterias in which mixture was used	Frequency of use percentage	Total amount of mixture offered in pounds	Amount of mixture used in pounds	Percentage of mixture consumed	Relative use index
$NaHCO_3$	9	9	100.0	21	19.1	91.0	1.91
NaI	16	16	100.0	56	46.0	82.4	1.82
NaCl	16	16	100.0	56	40.0	71.5	1.72
NaH_2PO_4	16	16	100.0	56	41.1	62.3	1.62
$CoCl_2 \cdot 6H_2O$	16	5	31.2	56	2.8	5.0	0.36
KCl	16	4	25.0	56	2.0	3.6	0.29
$MgCl_2 \cdot 6H_2O$	16	3	18.7	56	1.7	3.0	0.22
$(NH_4)_2HPO_4$	6	1	16.7	26	0.7	3.0	0.20
$CaCl_2 \cdot 6H_2O$	16	2	12.5	56	1.5	2.7	0.15
H_3PO_4	5	0	0	8	0	0	0
KH_2PO_4	5	0	0	14	0	0	0
$Mg_3(PO_4)_2 \cdot 4H_2O$	1	0	0	2	0	0	0
NH_4Cl	16	0	0	12	0	0	0
HCl	4	0	0	9	0	0	0
$CuSO_4$	16	0	0	56	0	0	0
$FeSO_4 \cdot 7H_2O$	14	0	0	56	0	0	0
H_2SO_4	15	0	0	16	0	0	0
$(NH_4)_2SO_4$	8	0	0	28	0	0	0
CaI_2	5	0	0	11	0	0	0
MgI_2	4	0	0	6	0	0	0
NH_4I	5	0	0	11	0	0	0
$KHCO_3$	4	0	0	6	0	0	0
Control	16	0	0	56	0	0	0

RESULTS OF STUDY

Mineral cafeterias. The results of sixteen mineral cafeterias are given in Table 1. An index number has been calculated for each compound to obtain a comparative use rating for the compounds tested. This index number was obtained by adding the percentage frequency and percentage of mixture consumed and dividing the sum by one hundred. On the basis of this rating, all sodium compounds received a much greater use than did any other compound.

Chloride compounds, other than sodium chloride, received only a minor amount of use. A check of the percentage frequency and the percentage of mixture consumed reveals that both values are low.

Phosphorus compounds other than sodium phosphate and ammonium phosphate received no use. Ammonium phosphate was used only once and in such a minute amount that little significance can be accorded its use in view of the extensive use on all sodium compounds.

Soil impregnation tests. Table 2 presents the results obtained from five soil impregnation tests. The percentage of volume use was obtained by assuming the volume use on sodium chloride to be 100 per cent and calculating the remaining percentages from this standard. The index number was obtained in the same manner as for mineral impregnation tests. This method of rating again shows that all sodium compounds received more use than did any other compounds.

Potassium, magnesium, and calcium chloride all received use, but a check of frequency of use and percentage of volume consumed reveals that both values are low in comparison with those for sodium compounds.

TABLE 2. COMPARATIVE USE BY BIG GAME ANIMALS OF FIVE SOIL IMPREGNATION TESTS IN WESTERN MONTANA FOR A TWO YEAR PERIOD (1951-52)

Compounds used for soil impregnations	Number of times compound was offered	Number of times compound was used	Frequency of use percentage	Total pounds of treated soil consumed (Approximate)	Percentage of volume used	Relative use index
NaCl	16	15	93.7	436	100.0	1.94
NaI	18	16	89.0	403	92.5	1.82
NaH_2PO_4	13	7	53.8	176	40.4	0.94
KCl	18	10	55.5	50	11.5	0.67
$MgCl_2 \cdot 6H_2O$	10	2	20.0	6	1.4	0.21
$CoCl_2 \cdot 6H_2O$	18	1	5.6	3	0.7	0.06
$CaCl_2 \cdot 6H_2O$	18	0	0	0	0	0
$CuSO_4$	18	0	0	0	0	0
$FeSO_4 \cdot 7H_2O$	16	0	0	0	0	0
H_2SO_4	9	0	0	0	0	0
$(NH_4)_2HPO_4$	2	0	0	0	0	0
H_3PO_4	3	0	0	0	0	0
$Mg_3(PO_4)_2 \cdot 4H_2O$	1	0	0	0	0	0
$(NH_4)_2SO_4$	6	0	0	0	0	0

TABLE 3. COMPARISON OF VARIOUS CHEMICAL PROPERTIES AND ELEMENTS IN LICK AND NON-LICK AREAS OF 18 NATURAL LICKS IN WESTERN MONTANA

Lick number	pH		Water soluble salts		Element																			
					P^1		P^2		Fe^1		Fe^2		S^2		Cl^2		Ca^2		Na^2		K^2		Mg^2	
	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N
1	7.97	6.75	620	123	2	7	0	1	47	4	2	0	7	17	15	21	6,810	4,683	297	131	1,072	241	1,568	909
2	8.15	6.74	620	113	11	17	0	10	78	13	2	1	25	5	7	12	5,133	2,346	818	72	1,289	237	986	538
3*	7.70	6.34	2,220	**	..	..	0	0	..	..	6	8	110	5	48	0	5	17	245	6	13	2	11	0
4	8.91	6.50	1,160	873	1	1	1	0	18	60	1	2	82	430	58	30	2,963	4,081	1,247	87	322	168	1,021	506
5	8.42	6.53	383	**	1	1	0	0	96	74	1	0	155	75	29	33	4,433	1,873	53	70	34	28	541	448
6	7.91	7.79	517	255	1	9	0	1	168	32	2	1	19	3	17	12	8,300	5,937	268	157	209	510	1,669	1,347
7	7.38	6.81	1,640	360	1	16	0	1	24	25	1	1	623	0	45	14	4,842	3,890	165	47	206	70	785	434
8	8.38	7.71	1,120	460	1	1	0	1	20	4	1	0	23	0	72	0	6,963	8,903	841	245	279	346	2,974	1,537
9	7.76	6.71	937	**	16	21	1	3	9	10	1	3	8	19	150	0	1,051	875	200	83	95	88	419	234
10	9.45	6.78	500	200	7	10	0	1	69	10	3	2	13	25	99	0	3,340	875	149	83	47	88	759	234
11	8.58	6.36	293	**	4	35	1	6	5	29	2	4	5	9	13	0	467	568	48	69	16	82	162	152
12	9.76	6.53	1,347	**	3	21	0	5	5	7	1	1	85	8	70	0	712	680	284	60	59	31	414	250
13	9.04	6.83	313	**	1	9	0	3	4	16	0	2	18	0	33	91	1,437	430	148	57	23	20	822	107
14	8.10	6.50	787	193	1	16	0	8	42	16	1	0	85	3	2	12	4,840	2.606	228	139	172	37	849	334
15	8.28	6.50	600	193	9	16	5	8	14	16	1	0	3	3	47	12	1,440	2,606	161	139	71	37	437	334
16	8.44	6.65	4,067	857	10	32	3	5	4	1	2	1	1.226	25	271	294	3.147	3,800	3,229	314	754	410	1,289	818
17	7.94	6.19	3,147	217	2	11	0	0	3	3	1	2	1.100	0	200	33	2,877	3.193	3.830	416	658	506	1,209	1,202
18	8.47	6.69	2,187	410	2	15	0	1	15	6	1	0	140	10	76	34	4,950	4,197	2.560	108	411	366	1,249	1,112
Average	8.37	6.72	1,248	236																				
Maximum	9.76	7.79	4,067	873																				
Minimum	7.38	6.19	293	**																				

All numerals (except pH values) represent parts per million.
L = Lick areas.
N = Non-lick areas.
1 = Extracting agent at a pH of 4.00.
2 = Extracting agent at a pH of 7.00.
* = Water sample from a spring lick.
** = Water soluble salts below 100 parts per million were not detectable.

Chemical analyses. The results of the chemical analyses are given in Table 3. The values given for each lick and non-lick area are the average of three samples from each area.

The average pH value of all lick samples was 8.37 and of the non-lick samples 6.72. No lick samples were found to be acid in nature nor were any lick samples found to have a lower pH value than the corresponding non-lick samples.

All lick areas contained more water soluble salts than the corresponding non-lick areas, and the average water soluble salt content of all lick samples combined was 1,248 parts per million as compared to 236 parts per million for the combined non-lick samples.

Calcium, magnesium, sodium, and potassium were found in fairly large amounts in all lick areas, while chlorine, sulphur, and iron were present in smaller amounts. Phosphorus was detected in minute quantities in all but one lick area.

DISCUSSION

The extensive use of all mixtures containing sodium ions, in both the mineral cafeterias and soil impregnation tests, shows sodium to be the element preferred by the big game ruminants in all study areas. If the conclusions of Richter (1937) can be applied to big game, sodium must be needed to fulfill a deficiency in their diet. However, since it is not known if these conclusions can be applied to big game, the possibility of these animals possessing an acquired taste for sodium cannot be disregarded. Murie (1951) suggests an acquired taste for salt may be responsible for its extensive use by elk. Mineral nutritional studies will no doubt have to be conducted, possibly with penned animals, before it can be determined if the use of sodium is due to a deficiency or an acquired taste. However, the bulk of available literature indicates that sodium is needed by domestic livestock in greater quantities than is found in natural foods, and therefore, the results of the mineral preference tests will be assumed to indicate a sodium deficiency.

The results of the chemical analyses are somewhat more difficult to interpret. If all licks were being used to obtain the same mineral, then this desired mineral should be present in all lick areas in greater concentration than in the corresponding non-lick areas. Examination of Table 3 reveals that only magnesium fulfills this requirement, but since a desire for magnesium compounds was not evidenced in the mineral preference tests, it is doubtful if magnesium is the desired mineral present in natural licks. Magnesium also is in fairly high concentrations in the non-lick areas and so it would seem that the forage plants should contain an adequate supply of magnesium.

A desire for magnesium apparently does not satisfactorily explain natural lick use; consequently, potassium and sodium must be examined since both occur in greater concentrations in the lick area in the majority of lick localities. Potassium is one of the major mineral constituents of plants, and inasmuch as the results of the mineral preference tests did not disclose a desire for potassium compounds, it is very unlikely that natural licks are being used to fulfill a need or desire for this mineral.

If the results of the sodium analyses are interpreted in light of the findings of the mineral preference tests, the evidence strongly indicates that big game ruminants in western Montana are utilizing natural licks to obtain sodium. Experiments in plant physiology have shown that plant life, with the exception of halophytic species, absorbs only a small percentage of the sodium present in the soil. Since the sodium concentration in non-lick areas is relatively small, the possibility exists that forage species may be unable to supply the quantity of sodium needed by big game.

Examination of Table 3 reveals that licks number 5 and 11 appear to contradict the conclusions that natural licks are being used to obtain sodium. However, licks number 12 and 13, in the same general locality as lick number 11, show a higher concentration of sodium within the area of lick use; this also holds true for lick number 4, which is in the same general locality as lick number 5. In view of these facts, it appears that an error may have been made in collecting samples from licks number 5 and 11.

Additional analyses and investigation of these two licks may prove that sodium is not their attracting mineral, although in view of the agreement of the results in the remainder of the licks investigated, it seems unlikely that these two licks would be exceptions.

MANAGEMENT SUGGESTIONS

The results of this study have strongly indicated that sodium compounds should be used as a management tool to counteract the attracting power of natural licks. Additional research may determine the relative attracting power of the various sodium compounds, but on the basis of our present knowledge, the use of sodium chloride would appear to be justified.

The management practice of placing sodium chloride on big-game ranges, if carefully planned, should produce the following results: (1) a reduction in the numbers of big game using natural licks on winter ranges during the spring and summer months; (2) a more even utilization of available forage which would result in over-all range improvement; (3) prevention of excessive damage to private pastures and cultivated crops by drawing big game away from these areas and holding them on desirable non-agricultural ranges.

Future research as regards salting programs should be designed to determine the following: (1) the proper time and area of placement of salt on various ranges; (2) the type of sodium compound to be used since there appears to be some doubt as to whether maximum results are being obtained by the use of the block type of salt; (3) the sodium requirement of big game ruminants throughout the year to indicate if sodium compounds will be effective as an attracting agent at all times of the year.

SUMMARY

Mineral preference tests in the form of mineral cafeterias and soil impregnation tests have shown sodium to be the mineral preferred by big game ruminants in all study areas in western Montana.

Chemical analyses and comparison of lick and non-lick samples have strongly indicated that natural licks in western Montana are used by big game for their sodium content.

The use of sodium chloride as a management tool to counteract the attracting power of natural licks in western Montana is supported by the results of this study.

ACKNOWLEDGMENTS

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DISCUSSION

DR. FALLIS: Another interesting paper relating to the nutrition of animals, undoubtedly of great importance. I am sure some of you must have some questions to ask the speaker.

MR. BENSON (Nova Scotia): I was wondering whether Mr. Stockstad had made any comparison of his findings on deficiencies or possible deficiencies of the licks with results of soil surveys by the agricultural people.

MR. STOCKSTAD: No, but in one of the areas in which we studied, I think some studies were carried out in a wilderness area. You see, non-licked samples should give us the representative mineral content of our unlicked aras.

DR. FALLIS: I wonder, Mr. Stockstad, whether you have any indication of animals other than big game using the licks and whether your studies showed a difference between the more or less natural licks and the ones in which you impregnated the soil.

DR. STOCKSTAD: As I understood your question, you are wondering whether the greatest use was on the mineral cafeteria or the soil impregnated areas, is that it?

DR. FALLIS: Yes.

DR. STOCKSTAD: Very few tests were run to find whether the ones that had the greatest use were the mineral or soil-impregnated areas. However, those that have been run show that the greatest use was where the mineral cafeterias were located.

On the other animals using the licks, we never made extended observation as to what animals did use the licks other than those that were observed; but around a camp one time where we had been throwing out dish water, we saw some ground squirrels feeding on the soil, but I don't know that we ever saw any indications of any animals other than big game animals which made use of the licks.

MR. BOSAEUS (Sweden): I am from Sweden, and I would like to ask one question. That is, have there been any reports on the way these licks have extended the growth of antlers? The reason I ask this is because I think in Germany over ten years ago, they tried to put forth the theory that by means of artificial licks, cafeterias, you could make better antlers. I think it was roe deer they tried it on mostly.

I know other European countries have tried it, too, and I don't think they have ever been able to prove anything. Therefore, I would like to ask if in America there has been any report on that, if these licks make bigger antlers. If there is any difference in the growth, we could get better antlers on moose or deer by moving them to artificial licks.

MR. STOCKSTAD: That certainly is an interesting observation, and I regret to say that to my knowledge there have been no studies of that made here in the United States. I think myself that it is a definite subject that should be studied because the possibilities do exist that larger antlers, larger animals, and healthier animals can be developed through artificial salting programs.

DR. FALLIS: Does anybody have a comment to make to our visitor from Sweden?

CHAIRMAN CHEATUM: I might comment just a little on that question from Sweden. We have discovered here that we have a great variety in the extent of antler development of our big game that is very obviously closely related to their nutritional level. Undoubtedly there are other factors involved in the production and development of antlers, which would involve vitamins too, and the question has been quite commonly raised among sportsmen with the object of developing a higher frequency of trophy heads and larger trophy heads.

One of our main problems in North Amreica is striking a reasonable balance between animal numbers and range carrying capacity to support the normal health of animals, rather than trying to achieve any spectacularly great antler development or over-all skeletal development or size in those animals.

Where you can really conduct pin-point management and you have your animals under more direct control, you might very well make that an objective.

I want to thank the participants for a very stimulating group of papers. It is very satisfying to see the basic type of investigation that is being done.

The faster we can translate these basic facts into application in the field in our big management problems, the better; and we just hope that this tempo of getting to the facts of life about these animals we are doing our best to manage will be stepped up.

I thank you for your kind attention, and this session is closed.

TECHNICAL SESSIONS

Monday Afternoon—March 9

Chairman: ROBERT S. CAMPBELL
Professor, University of Missouri, Columbia, Missouri

Discussion Leader: GEORGE W. BENNETT
Head, Aquatic Biology Section, Illinois Natural History Survey, Urbana, Illinois

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FRESH-WATER RESOURCES

UNDERWATER TELEVISION IN FRESH-WATER FISHERIES RESEARCH

J. P. CUERRIER, F. H. SCHULTZ, AND V. E. F. SOLMAN
Canadian Wildlife Service, Ottawa, Canada

The more a worker specializes in one branch of science, the more he becomes dependent on other branches for his new ideas, his tools, and his research methods. Thus it is that limnology, the science of fresh-water fisheries, has within the last year or two made a sudden leap forward by linking hands with the science of electronics.

In September, 1951, the idea of using underwater TV in fresh-water fisheries research occurred to Dr. V. E. F. Solman, Chief Biologist of the Canadian Wildlife Service, after learning of the Royal Navy's use of this device in locating the lost submarine *Affray.* Some months later he heard of underwater TV experiments being carried on by the National Research Council in Ottawa. The authors discussed these experiments with the Research Council staff, examined their equipment, and began negotiations for testing it in fisheries research. The outcome was the first use of underwater TV in the field of limnology in North America, and possibly in the world, in September, 1952.

It is this experimental use which we wish to describe briefly, even though we realize the limitations of the observations and the inadequacies of the present equipment. If this paper arouses your curiosity regarding underwater television reearch and leads to extension and development of similar experiments, we shall feel that we have achieved one of our major objectives.

In this paper we shall outline the history of underwater television, describe the Canadian unit and the operations at Lake Minnewanka, Banff National Park, Alberta, and finally point out some applications of underwater television for studying and solving theoretical and practical fisheries problems.

HISTORY OF UNDERWATER TELEVISION

An underwater television unit was first used at the Bikini atomic operations in 1947. During the same year, an underwater television unit was tested briefly at Cornell University.

In the autumn of 1951, underwater television became front page news in connection with the loss of the Royal Navy submarine *Affray*. After other methods had failed to distinguish the hull of the *Affray* from hulls of other wrecks in the same area, located by sonic means, the Royal Navy and private enterprise cooperated in building an underwater television unit by means of which the submarine was positively identified. Even its nameplate was readable on the TV screen. The underwater casing in which this camera was mounted was bulky, weighing almost one ton. It was provided with lights to illuminate the area viewed but had no self-propelling mechanisms. It was a start, however, and the value of underwater television was now a recognized fact.

In Canada, Engineer W. F. Torrington of the Radio and Electrical Engineering Division of the National Research Council, was assigned the task of consructing an underwater TV unit in 1949. Its development took considerably longer than that of the British equipment, but the additional features it provided were of great value and were ample compensation for the delay. The unit was completed in the autumn of 1951 and was tested for its ability to operate in deep water without leaking and to transmit an image. It was used in Lake Ontario to assist historians in studying Kingston Harbor and sunken boats about the vicinity of the harbor.

Mr. Torrington had made several developments and improvements in the equipment when the Canadian Wildlife Service sought permission to use it in January, 1952, to study fisheries problems. Without discussing the electronic features of this Canadian underwater TV unit, we shall briefly describe the various components to indicate their interrelationships.

DESCRIPTION OF THE APPARATUS

The underwater apparatus is enclosed in a water-tight cylinder 3 feet long and 1½ feet in diameter and weighs about 300 pounds. A panel of four sealed-beam spotlights with a total light output of 300 candlepower is mounted above the front of the cylinder. Near the center of the end of the cylinder is an additional 75-candlepower spotlight with a yellow filter, but this spotlight was not functioning during our operation. In the lower part of the front of the cylinder a half-inch plate-glass window 4 inches in diameter provides the opening for the lens of the television camera. At the top of the cylinder is a chain for the attachment of hoisting gear. At the bottom of the cylinder is another chain to which additional weights may be attached to counteract the slight buoyancy of the cylinder and cause it to sink. The length of the chain hanging from the under side of the cylinder regulates the distance between the cylinder and the lake bottom; when the weight of part of the chain rests on the bottom of the lake the cylinder reaches a buoyant equilibrium. Two propellers are located at the rear end of the cylinder. One is enclosed in a tunnel which branches to each side of the cylinder. The current of water produced by the propeller passes through the tunnel and moves the cylinder forward or backwards. The other propeller, mounted below and at right angles to the first, turns the cylinder to the right or left.

The cylinder contains the television camera, the main component of which is the image orthicon tube. This tube is sensitive enough to provide a clear image when used with an f 4.5 lens in light so weak that no reading can be obtained with a Weston Master or General Electric PR-1 photoelectric exposure meter. The camera has two interchangeable lenses, of 2-inch and 5-inch focal length. Changing of the lenses and also focusing and diaphragm control are carried out by remote control from the surface, using small reversible electric motors. The cylinder also contains three additional reversible motors. Two of them operate the propellers and the other moves a 50-pound lead plate placed near the bottom of the cylinder. Movement of this lead plate forward or backward causes the cylinder to tip away from or toward the horizontal as may be required.

The cylinder is connected to the surface apparatus by a long waterproof cable, about one inch in diameter, which contains 25 separate insulated wires. Three small coaxial conductors are fastened to the outside of this cable. These conductors all pass into the cylinder through a watertight gland on the top of the casing. Two-thirds of this 500-foot cable is buoyed up by attached cedar floats to avoid restricting the movement of the cylinder and to make handling easier when the cable is being pulled out of the water. The cylinder is thus free to propel itself anywhere within a 500-foot radius of the surface units.

The surface parts of the closed television chain may be mounted on shore or on a boat; we used a boat. The equipment consists of a 6 by 8 inch screen for direct observation, and a 3 by 4 inch screen with a synchronized 16 mm. movie camera for making permanent photographic records. The smaller screen produces a direct positive or negative image, whichever is desired. There are also two remote-control panels. One controls the lights mounted on the cylinder, the lens turret, the lens-focusing aparatus, the iris diaphragm and reproduction of the image on the screen, and the other controls the inclination, rotation, and forward and backward movement of the cylinder. In order to see the screen more clearly, the front section of the boat had to be kept in semi-darkness, and as this made it difficult to write, the observer used a tape recorder to make notes on his observations of the screen. A hoist attached to the boat was used to handle the cylinder when it was out of the water. The total electric power required was at least 3 kilowatts.

THE LAKE MINNEWANKA OPERATIONS

On September 5th, the National Research Council party arrived in Banff with the equipment. This party consisted of Mr. W. F. Torrington, engineer in charge, Mr. M. Dale and Mr. R. Smith. The party from the Canadian Wildlife Service was already there, as its members had been carrying out investigations in Banff National Park since the early spring. This party consisted of Mr. J. P. Cuerrier, Chief Limnologist, and Limnologists J. C. Ward and F. H. Schultz. A 7½-ton patrol boat owned by the park authorities and used in the experiments was operated by Mr. J. E. Stenton, district warden.

The equipment could not be used as soon as expected. Existing field conditions called for several changes in the apparatus, and trouble which had developed during the 2,200-mile trip by railroad had to be repaired.

Electric power was supplied by two small gasoline-powered generators. Since the space on board the boat was limited, and since the noise and vibration of small gasoline engines was annoying and might have affected the delicate apparatus, the 1½- and 2-kilowatt generators were placed on a small skiff towed behind the large boat. An attempt was made to maintain the synchronization of these two generators in order to have a single power supply with an adequate frequency stability. This proved to be impossible and rewiring was necessary so that the two power supplies could be used separately. The 1½-kilowatt generator, which proved to have the greater frequency stability, was connected with the television screen circuit, and the 2-kilowatt generator produced the power required for movement of the cylinder and adjustment of the lens system.

On Monday, September 22, 1952, the first successful underwater television observations were made at Lake Minnewanka. The first reaction of the members of the party was one of great enthusiasm as they viewed the bottom of the lake with its sticks, stumps, and rocks. When the sight of familiar objects is brought to the observer from depths as great as 100 feet under the surface of the water even sticks and rocks take on a new significance. Observations with this unit were carried out almost every day, at times ranging from five o'clock in the morning until after eleven o'clock at night. A total of about 45 hours was spent in actual observation.

Several types of observations were carried out in Lake Minnewanka with this equipment. It was found, for example, that on one day, even at depths of 60 feet where the cylinder could not be seen from the boat, the amount of light available was such that artificial illumination was not required to examine the structure of the bottom. On another day the visibility even at depths of 30 feet was nil without the lights. It was at first believed that some defect in the apparatus was responsible for the decrease in visibility, but it was soon realized that a strong wind had caused a considerable amount of "stirring up" along the shores, with the result that the lake waters became quite turbid with suspended material. Further examination revealed that certain areas, particularly those with gravel bottom, did not suffer from such heavy turbidity in the water.

Lake Minnewanka, a body of water in Banff National Park with a native population of lake trout, had its surface level raised 64 feet in 1941 by construction of a dam for hydro-electric power development. Each winter the surface water level is drawn down about 35 feet for power production.

The main questions to be answered by this study were: To what depth do the lake trout spawn, and on what type of lake bottom?

Since the original spawning grounds were now under deep water, it was also of importance to know whether these areas were still being used, or whether other spawning areas were being used. Because of the drawdown in the water level which occurs during the winter each year, the spawning which takes place in shallow areas was considered to be lost. Since the young year-classes of lake trout were well represented in the population, successful spawning must have occurred after 1941. The television tests enabled us to search rock beds for lake trout eggs. After we had learned to recognize lake trout eggs by actually dropping eggs in front of the camera and observing them, the equipment was taken to known spawning areas during spawning periods. Lake trout eggs were then seen lying on top of rocks and beside sticks in waters to depths of about 80 feet.

Our problem of determining the extent of potential spawning areas in Lake Minnewanka and their availability to lake trout was much simplified by using this television chain.

Another problem was the examination and determination of the natural shelter for larval and smaller sizes of fish.

Does Lake Winnewanka have the type of bottom that favors the survival of small fish, that is, with rocks and debris which afford them protection and shelter? An answer to this question was obtained simply by looking at the bottom structure. It had been presumed that the erosion of material from recently flooded areas would have resulted in sand and gravel covering much of the bottom of Lake Minnewanka, to the detriment of small fish. By direct observation with underwater television we found that no such change had occurred. Many excellent shelters were seen along the shores and in the depths of the lake. This condition helped to explain the large numbers of small fish in the lake, since the newly hatched fry could immediately find many rocks, stumps and other debris to protect themselves from predation by larger trout.

Examination of the lake bottom by means of underwater television also made it possible to estimate the distribution of bottom fauna, which could not have been done by any other method. Evidence of feeding activity of fish was noted. There is no doubt that the scope and variety of observations will be greatly expanded by further experience.

SUGGESTED APPLICATIONS OF UNDERWATER TELEVISION

The possible uses for underwater television in freshwater fisheries research are bounded only by one's imagination, and by limitations of the equipment and of the environment. Field research in fisheries problems has always been hampered by the fact that direct observation is difficult and, for many phases, is impossible. For this reason sampling techniques and analysis have formed the basis of previous observations.

As it would be premature to attempt to outline all the potential uses of the unit at this stage, we shall limit our remarks to a few items.

Laboratory tanks are built to study physiological reactions of fish under such conditions as varying oxygen concentrations, temperatures and pressures. These studies can now be made by performing experiments with caged fish in their natural habitat and observing them with a television camera.

Another age-old question which arises when fisheries biologists congregate is "Do fish sleep?" It was reported recently that a Wisconsin diver found thousands of white perch lying quietly on the bottom of a lake. He proposes the theory that perhaps they escape predation in this manner. It seems but a simple task now to check this fact by extended TV observation over a much longer period than that possible for a diver to remain submerged.

Aquatic biologists have often been concerned with the efficiency and accuracy of their sampling devices. Such questions could be easily answered by setting a gill net in the lake and watching the net by television over a certain period of time. It would be a simple matter to determine how many fish approach the net and turn away; how many come up to the net, run along its length and pass around; how many fish pass over the top of the net, and how many smaller fish are not caught because the particular mesh size is too large. In other words, the efficiency of a net for sampling various species of fish could be estimated. Similarly while sampling a muddy area of the lake bottom with an Eckman dredge, it is actually impossible to see how much loss of mud there is in sampling the soft flocculent type of bottom as compared to a harder clay-like bottom or a less cohesive sand or silt bottom. The efficiency of many underwater sampling devices could be determined visually.

The impounding of water by large power dams often produces challenging problems for the fisheries biologist. Annual fluctuations in the water levels may be of less importance than the fact that the spillways, sluice gates and turbines often take a large toll of the fish population. Because of the currents, direct observation of the action that is taking place near and around these structures becomes extremely dangerous for a diver and in many cases is impossible. Underwater television would permit a look at these areas with no danger to human life.

Clam harvesting is an extensive industry along the east and west coasts. One packing company alone is known to employ 35 boats which do nothing but harvest clams. A difficulty encountered by these operators is in locating the clam beds which occur in water between 45 and 90 feet deep. The boundaries of the clam bed must be known in order to manage the harvest to best advantage. Underwater television could probably be applied here with great success. It would seem feasible to locate and mark the limits of each clam bed and even to study the clam population with a view to forecasting the future crop.

The penetration of natural light, an important physical aspect of aquatic study, could easily be determined by means of underwater television. A series of colored discs placed in front of the camera could reveal the range of vision possible by natural light and the spectral composition of the light at a particular depth. Turbidity at any desired depth could be studied, as well as its effects on the transmission of light.

Another application is the study of aquatic organisms under winter ice cover. Very little is known, at the present time, concerning the activity of fish and the activity and distribution of bottom fauna during these periods. Television observations in areas of water with low dissolved oxygen concentration may make it possible to determine if fish or other organisms can actually detect changes in oxygen content of water or if they blunder into areas of low concentration without suspecting it and are thus killed.

The examination of the structure of lake and sea bottom areas as an entity *"in situ"* has been considered very desirable by many workers. Direct observation of the physical features of a lake bottom is now possible. The determination of rate of deposition of the dead and dying planktonic and other detritus that "fills in" a lake is very important to the chemical-nutrient relationships in a lake. The relationships of these deposits at various depths and at different locations in a lake have received much attention, with limited success. It may be simple now merely to place markers on a lake bottom and to observe these markers from time to time without any disturbance to the process of settling.

A recent development in television recording pioneered by Bing Crosby Enterprises permits the recording on magnetic tape of both a visual image and the comments of an observer. This would allow immediate review of the visual record and automatic synchronization of the visual and spoken records.

Since the underwater unit is self-propelled and can be connected to the control and viewing units by very long cables, it is possible to investigate a large area of water without the use of a boat by locating the above-water units on shore.

Since images picked up by an underwater television camera have already been broadcast in England, it is possible that millions of people in North America will soon be able to see live TV broadcasts from the depths of the Great Lakes or of the ocean, and will be able to witness the activities of fish and other forms of freshwater or marine life.

Observations made by underwater television have numerous advantages over those made by divers, who are limited in their operations by pressure, temperature, time and specialized biological knowledge. The element of danger to human life is eliminated also.

Underwater television, however, has its own limitations, many of which may be overcome by future refinements.

LIMITATIONS OF UNDERWATER TV

Our report on underwater television would not be complete if we did not point out what we have learned regarding its limitations and possible improvements. The experience gained in the work on Lake Minnewanka, therefore, is valuable since several shortcomings of the particular unit used there could easily be avoided in the construction of other units. Some of these difficulties, as we see them, can be summarized as follows.

The first and most formidable difficulty in the use of underwater television is the problem of seeing through turbid water. Turbidity seems to be the only visual limitation that cannot be overcome directly when natural or artificial light is used. High turbidity in the water prevents a clear image from being picked up by the image orthicon tube. It is not inconceivable that light in other than the visual wave lengths could solve this problem, or that certain filters might decrease the effects of turbidity. Other limitations which are apparent from our use of the Lake Minnewanka apparatus concern the maximum depth of water in which it can be used and the ability of the surface observer to determine the depth and direction in which the cylinder is being operated. The maximum depth of operation is governed by the construction of the waterproof casing and is therefore a mechanical problem. It should be possible to construct a cylinder capable of being used at depths greater than the 100 feet to which we were limited. A record of the depth directly under the boat is very easily obtained, but with the free maneuverability of the camera cylinder the depth in which it is located may be constantly changing and may differ widely from that under the boat. This problem could be solved if a pressure-sensitive unit to indicate depth of water was mounted on the cylinder and incorporated into the visual pick-up, or relayed electrically to a depth gauge on the surface.

The authors further believe that a compass installation in the underwater cylinder, the reading of which could be relayed to the surface in a visual field, would greatly enhance the value of any future underwater television apparatus. This would provide an easy means of knowing both the direction in which the cylinder is pointing, and the direction in which it is being propelled. An inclinometer would also be a useful addition since without it the vertical orientation may be unknown and it may be difficult to differentiate a sloping bottom from a horizontal one by means of the screen image.

A further difficulty with the apparatus as it was used in Lake Minnewanka was the size and weight of the various parts, which required a large boat fitted with a winch to accommodate and handle them.

The size and weight of the components can probably be reduced so that underwater television observations may eventually be possible from a small outboard motor-powered craft.

DISCUSSION

DR. BENNETT: This paper is now open for discussion. I am sure there are a lot of things which have come to mind in seeing this new type of apparatus.

DR. CARL L. HUBBS (Scripps Institution of Oceanography, LaJolla, California): May I ask what is the maximum length of cable you have been able to use satisfactorily?

MR. CUERRIER: The cable was 500 feet long, from the boat to the casing.

MR. RALPH HILLS (Michigan): On behalf of the American Fisheries Society, I am pleased to be able to announce that the Canadian Government has accepted our invitation extended by Dr. Sneeberger, chairman of our Program Committee, to demonstrate this television equipment on the occasion of our 83rd annual meeting to be held next September. The demonstration will be held on September 16, in the morning at Lake Mendota in Madison. It will be a feature of the joint field day which is held on the common date of meetings of the International Association and the American Fisheries Society. Both meetings are to be held in Milwaukee next fall: the Association, the early part of the week; the Fisheries Society, from the sixteenth to the eighteenth.

At first, we thought the demonstration would be held on Lake Michigan. That lake is notoriously undependable. The smaller lake, I think, may have more fish and give us smoother water. We would be very happy to have any of you who are interested attend that meeting to watch the demonstration.

THE IMPORTANCE OF GROUND WATER TO TROUT POPULATIONS IN THE PIGEON RIVER, MICHIGAN[1]

NORMAN G. BENSON
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Many fishery workers have noted variations in population densities in different sections of the same trout stream (Needham, 1938; Allen, 1951). The ecological factors responsible for these variations have never been analyzed thoroughly. Leopold (1933) stated that limiting factors were the fundamental determinants of abundance and composition in game populations and hence their management. Knowledge of limiting factors is also basic to fish management. The purpose of this study was to determine which ecological factors were acting as limiting influences on the density of trout populations. The investigation was conducted on four study areas, each 400 yards in length, of the Pigeon River, Otsego and Cheboygan Counties, Michigan. Native-spawned brook trout (*Salvelinus f. fontinalis* Mitchill) and brown trout (*Salmo trutta fario* L.) were the species considered. Chemical, physical, and biological data were collected during all months of the year in the period from June 1950 to June 1952.

GENERAL METHODS AND RESULTS

The Pigeon River is a hard-water stream which originates in a series of cedar swamps near the village of Sparr, Michigan. It flows northward for about 60 miles and empties into Mullett Lake. The study areas were purposely selected for their varied populations of brook and brown trout. Population estimates were made by the mark-and-recapture technique, using trout collected with a direct-current electric shocker. Study Area I, located near the headwaters of the stream, had a large population of brook trout (estimated at 1,440 in July 1951). Study Area II, situated approximately midway from the source to the mouth of the stream, had a moderate population of brook and brown trout (estimated at 777 brook trout and 60 brown trout in July 1951). Study Area III, located three miles downstream from Study Area II, had a very low population of brook and brown trout (estimated at 87 brooks and 2 browns in July 1951). Study Area IV, located about 20 miles downstream from Study Area III, had a negligible population of brook and brown trout (estimated at 1 brook trout in July 1951). The populations of brook and brown trout were used to indicate the importance of each factor analyzed. No attempt

[1]Contribution from the Institute for Fisheries Research of the Michigan Department of Conservation.

was made to ascertain the relationships between these factors and growth or survival rates.

The chemical factors measured were: dissolved oxygen, methyl orange alkalinity, phenopthalein alkalinity, hydrogen ion concentration, and phosphorus. The chemistry of the water did not vary significantly among the study areas and did not appear to influence the density of the trout populations.

Physical factors of the stream investigated were bottom type, width, depth, percentage gradient, pool-riffle ratio, cover, temperature, surface ice, and ground water. Bottom type, width, depth, percentage gradient, pool-riffle ratio, or cover were not found to be basic in determining the populations of trout. Temperatures were collected in summer with maximum-minimum thermometers in each study area. The maximum temperatures recorded in the respective study areas were: I, 67° F.; II, 76° F.; III, 78° F.; and IV, 78° F. (Table 1). A limited number of winter water temperatures was also collected. Study Areas I and II showed generally higher winter temperatures (34° F. to 36° F.) than were recorded in Study Areas III and IV (32° F. to 33° F.) (Table 2). Surface ice was found to be an indicator of winter water temperature. The percentage of stream surface area covered by ice

TABLE 1. MAXIMUM AND MINIMUM TEMPERATURES (° F.) IN EACH STUDY AREA OF THE PIGEON RIVER, MICHIGAN, IN 1951. DATES INDICATED ARE THE BEGINNING AND END OF EACH PERIOD USED.

Study Area: I			II			III			IV		
Date	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.
3/31-4/16	44	34	3/14-4/1	42	32	3/16-4/19	47	34	3/23-3/30	40	32
4/16-5/2	58	34	4/1-4/17	45	35	4/19-5/2	64	36	3/30-4/25	46	34
5/2-5/12	58	42	4/17-5/2	60	34	5/2-5/25	71	50	4/25-5/4	62	38
5/12-5/25	62	42	5/2-5/14	62	46	5/25-6/1	70	53	5/4-5/11	60	48
5/25-5/31	64	50	5/14-5/25	66	52	6/1-6/8	70	52	5/11-5/26	68	52
5/31-6/9	61	46	5/25-6/1	67	53	6/8-6/14	68	58	5/26-6/1	66	56
6/9-6/15	62	46	6/1-6/8	66	52	6/14-6/22	77	54	6/1-6/8	68	52
6/15-6/22	65	51	6/8-6/14	68	55	6/22-7/2	74	56	6/8-6/14	68	56
6/22-7/2	64	52	6/14-6/22	74	58	7/2-7/6	74	54	6/14-6/22	71	60
7/2-7/6	62	51	6/22-7/2	70	58	7/6-7/14	78	56	6/22-7/2	71	59
7/6-7/14	65	50	7/2-7/6	68	54	7/14-7/20	78	55	7/2-7/6	69	56
7/14-7/20	66	51	7/6-7/14	72	60	7/20-7/27	78	57	7/6-7/14	71	60
7/20-7/27	67	54	7/14-7/20	75	64	7/27-8/3	76	59	7/14-7/20	74	58
7/27-8/4	67	50	7/20-7/27	76	60	8/3-8/11	71	54	7/20-7/27	78	71
8/4-8/11	58	50	7/27-8/3	75	62	8/11-8/17	71	54	7/27-8/3	75	63
8/11-8/17	64	50	8/3-8/11	69	57	8/17-8/25	70	52	8/3-8/11	70	58
8/17-8/25	61	48	8/11-8/19	70	57	8/25-8/31	73	56	8/11-8/17	70	58
8/25-8/31	64	54	8/19-8/25	68	54	8/31-9/7	68	51	8/17-8/25	68	56
8/31-9/7	60	48	8/25-8/31	70	59	9/7-9/15	70	49	8/25-8/31	72	61
9/7-9/15	65	46	8/31-9/7	65	55	9/15-9/21	65	58	8/31-9/7	61	54
9/15-9/21	61	45	9/7-9/15	68	53	9/21-9/29	64	42	9/7-9/15	69	52
9/21-9/29	61	42	9/15-9/21	64	50	9/29-10/6	60	44	9/15-9/21	64	50
9/29-10/6	56	43	9/21-9/29	64	44	10/6-10/12	53	47	9/21-9/29	64	44
10/6-10/12	51	40	9/29-10/6	60	45	10/12-10/19	58	44	9/29-10/6	60	43
10/12-10/19	54	42	10/6-10/12	53	43	10/19-10/26	53	43	10/6-10/12	53	43
10/19-10/26	53	42	10/12-10/19	56	45	10/26-11/2	50	37	10/12-10/19	57	45
10/26-11/3	50	43	10/19-10/26	53	43				10/19-10/26	52	43
			10/26-11/3	49	33				10/26-11/2	49	37

TABLE 2. WINTER WATER TEMPERATURES (° F.) IN EACH STUDY AREA OF PIGEON RIVER, MICHIGAN; DATA COLLECTED WITH NEGRETI-ZAMBRA REVERSING THERMOMETER.

Study Area I		Study Area II		Study Area III		Study Area IV	
Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.
11/6/50	42.0	11/11/50	51.0	11/11/50	50.0	11/7/50	41.0
1/11/51	34.1	1/18/51	35.0	1/15/51	33.1	1/8/51	32.0
1/19/51	35.0	1/25/51	32.5	1/28/51	32.1	1/20/51	32.0
2/6/51	34.2	2/2/51	32.5	2/16/51	32.9	1/24/51	32.0
2/16/51	32.7	2/14/51	32.5	12/2/51	36.0	2/2/51	34.2
3/19/51	38.0	3/14/51	38.0	12/19/51	32.2	2/13/51	32.7
12/19/51	38.0	12/2/51	36.0	1/5/52	36.0	12/19/51	32.1
1/5/52	33.5	12/19/51	32.1	1/28/52	32.1	12/24/51	32.0
1/7/52	32.9	1/7/52	32.8	2/18/52	32.2	1/16/52	35.0
1/28/52	32.2	1/28/52	32.1	2/29/52	33.0	2/18/52	32.0
2/9/52	33.0	2/20/52	33.2	3/18/52	39.2	3/18/52	33.8
2/20/52	34.6	3/18/52	38.0				
3/19/52	37.4						

was recorded periodically during the winters of 1950-51 and 1951-52. The maximum percentages of ice recorded were: Study Area I, 20 per cent; Study Area II, 75 per cent; Study Area III, 100 per cent; and Study Area IV, 100 per cent (Table 3). Aerial photographs, taken

FIGURE 1. STUDY AREA II ON JANUARY 31, 1952, GOOD TROUT HABITAT, DEVOID OF ICE COVER.

TABLE 3. FIELD OBSERVATIONS OF PERCENTAGE OF ICE COVER IN STUDY AREAS DURING WINTERS OF 1950-51 AND 1951-52[1]

Date	Study Area I	II	III	IV
1950				
Dec. 10	0	0	..	..
15	0	0	..	..
20	..	0	..	..
1951				
Jan. 8	..	..	..	100
9	..	..	95	..
10	..	..	..	100
11	0	..	..	..
14	..	..	50	..
19	0	0	..	..
25	..	..	..	95
29	..	50	..	..
Feb. 1	..	..	..	100
2	..	75	..	..
8	5	..	..	..
13	3	..	100	100
14	..	80	..	..
Mar. 1	0	..	..	..
14	0	..	..	..
15	..	..	..	10
16	..	0	10	..
30	..	..	0	0
Dec. 2	0	0	0	0
19	0	40	100	60
24	0	40	100	80
1952				
Jan. 4	..	..	..	75
5	0	0	0	..
7	0	0	..	..
8	..	..	..	75
16	0	0	0	75
28	20	50	100	100
Feb. 9	0	0	0	85
17	..	0	..	..
18	..	..	90	..
19	..	..	..	90
20	0	0	..	..
26	..	..	..	90
28	..	0	..	..
29	0	..	0	..
Mar. 5	..	0	0	..
6	0	..	..	75

[1].. indicates no observation made.

TABLE 4. DETERMINATIONS OF GROUND WATER SEEPAGE ENTERING SECTIONS OF THE PIGEON RIVER, MICHIGAN[1]

Date	Study Area Enclosed	Length of Section of Stream in Yards	Discharge Entering Section in cfs.	Discharge Leaving Section in cfs.	Surface Water Entering from Tributaries in cfs.	Net Increase in cfs.	Rate of Seepage—Per Cent Increase Per Mile
12/14/51	I	700	47.22	51.64	0.0	4.40	23.5
2/16/52	I	700	44.02	47.33	0.0	3.31	18.9
10/16/51	II	2,000	68.90	76.16	2.00	7.26	6.7
2/17/52	II	1,400	63.16	75.88	2.00	11.72	23.2
10/16/51	III	1,760	78.69	79.87	1.0	1.18	1.5
12/14/52	III	1,100	76.43	79.50	0.07	3.07	6.4
10/17/51	IV	5,280	119.90	127.90	7.1	0.90	0.3
2/19/52	IV	5,280	133.90	111.03	17.08	5.79	1.7

[1]Each section of stream studied enclosed a study area; discharge determinations were made with a Price current meter.
[2]cfs.—cubic feet per second.

FIGURE 2. STUDY AREA III ON JANUARY 31, 1952. POOR TROUT HABITAT, COVERED WITH ICE.

January 31, 1952, showed Study Area II to be completely devoid of ice and Study Area III to be almost completely frozen (Figures 1 and 2). The volume of ground water seeping into a section of stream was determined by measuring the stream discharge (volume of flow in cubic feet per second) at two points. Ground water seepage was considered to be the increase in volume of flow which could not be attributed to surface water inflow. Ground water, as determined by this "seepage run" method, was recorded as the percentage of increase in volume of flow per mile of stream. The maximum ground water recorded in the respective study areas was: I, 23.5 per cent; II, 23.2 per cent; III, 6.4 per cent; and IV, 1.7 per cent (Table 4). Water temperatures (including winter ice cover) were also used to indicate ground water seepage. To locate more definitely seepage in various parts of the stream, temperatures were taken in the gravel of the stream bed (two to three inches below the surface of the stream bed) with a Foxboro resistance thermometer. Those parts of the stream bottom with ground water seepage were warmer in winter and cooler in summer than nearby areas (Figure 3).

The biological factors studied were bottom food production and non-trout fish populations. Production of bottom food was estimated from

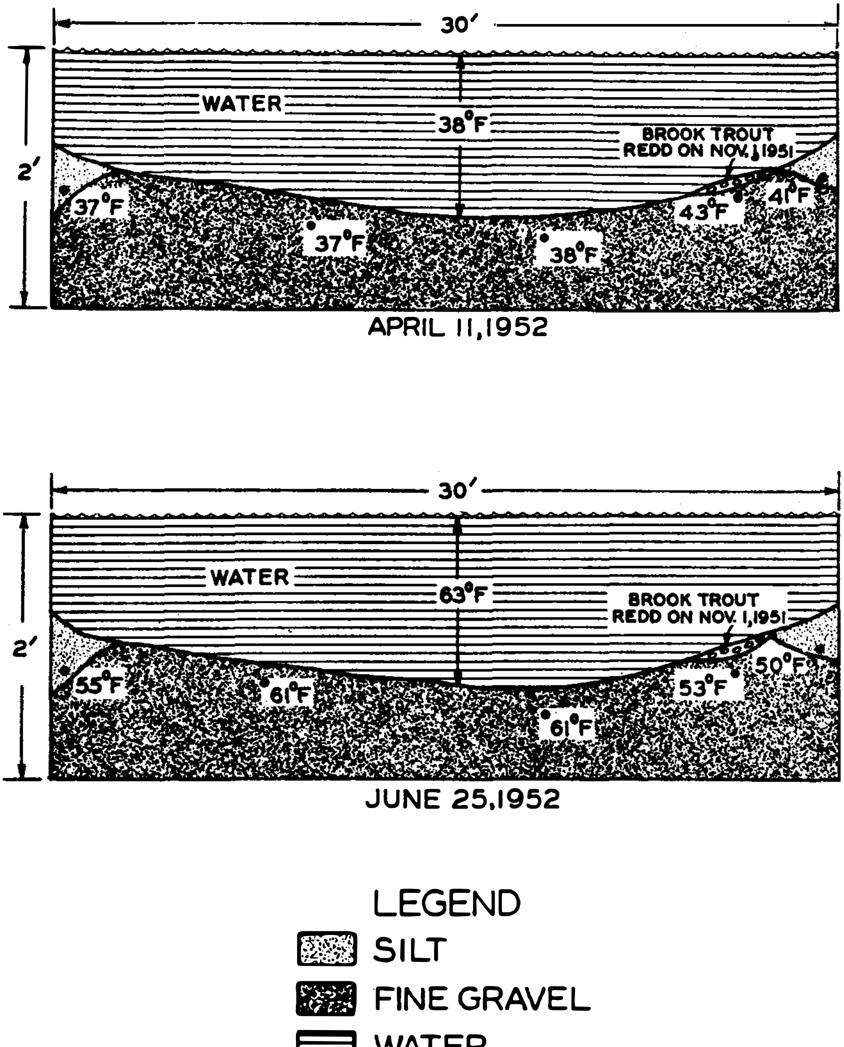

FIGURE 3. CROSS SECTION OF THE PIGEON RIVER STREAM BED WHERE BROOK TROUT SPAWNING WAS OBSERVED ON NOVEMBER 1, 1951. TEMPERATURES OF THE WATER IN THE BOTTOM SOILS AT THE LOCATION OF BROOK TROUT REDDS WERE WARMER ON APRIL 1, 1952, AND COOLER ON JUNE 25, 1952, THAN IN OTHER SECTIONS OF THE STREAM BED.

winter collections in each study area and could not be considered a factor that was limiting the trout production. There was no evidence that populations of non-trout fish species (principally white suckers, creek chubs, blacknosed dace, or sculpins) were influencing trout production significantly.

The amount of trout spawning was determined for each study area during the seasons of 1950 and 1951. The mean number of redds (trout spawning beds) observed in the respective study areas was: I, 36; II, 5; III, 0; and IV, 0. Ecological studies were made of trout spawning. Brook trout spawned on fine and coarse gravel, while brown trout utilized coarse gravel and rubble. Current velocities did not appear to affect the location of redds. Gradient of the stream bed over the location of brook trout redds was never greater than 0.2 per cent. Temperatures in the bottom soils at brook trout redds were warmer in early April and cooler in June than in other parts of the stream bed with identical bottom soil type, depth, and current velocity (Figure 3). Hence ground water was the only measured condition which could be consistently associated with spawning sites.

DISCUSSION

Ground water seepage was the main limnological factor which appeared to control the populations of brook and brown trout in the Pigeon River. This condition determined location of spawning areas and affected the numbers of all sizes and age groups. Several workers have pointed out the importance of cold water (a direct result of ground water in the Pigeon River) to the distribution of trout in streams and to the more practical consideration of locating trout hatcheries (Embody, 1921; Belding, 1928; Creaser, 1930; White, 1930; Hazzard, 1932; Ricker, 1934; Greeley, 1932). Brown trout can tolerate warmer temperatures in midsummer than can brook trout (*e.g.* Embody, 1921; Hobbs, 1948), but evidence in the Pigeon River indicated that they still required ground water for spawning.

Location of ground water seepage. Few biologists have attempted to locate ground water seepage, and a critical analysis of the means used in this study seems advisable. The methods employed in this investigation were: (1) seepage run, (2) summer water temperature, (3) winter water temperature, (4) winter ice cover, and (5) bottom soil temperature. Attempts to locate ground water by chemical methods were futile in the Pigeon River.

Seepage Run. This method is applicable if an accurate method of determining stream flow is possible on two points in the stream. Surface water influx must be determined and subtracted from the gain in volume of flow. The major limitation is that seepages cannot be determined for short stretches of stream (less than 700 yards in the Pigeon River) and ground water inflow, therefore, cannot be adequately localized as much as is necessary for some purposes.

Summer Water Temperatures. Water temperatures were satisfactory as an indication of ground water seepage only during the hottest periods of summer. At these times the temperature effects are chiefly limited to sections of the stream where ground water is actually entering the channel. When the stream surface is exposed to high air temperatures, water temperatures will rise accordingly unless there is an appreciable amount of ground water to offset this influence. During hot periods, therefore, sections of streams with much seepage will have markedly lower temperatures than surrounding areas with little seepage.

Winter Water Temperatures. Ground water seepage can be identified by water temperatures in winter because of its warming influence on stream water. When air temperatures reach 10° F. or below for a period of several weeks, a considerable amount of heat is necessary to prevent water from freezing. During the winter, ground water was the main source of heat in the Pigeon River. The use of winter water temperatures to identify seepage was limited, however, because the range of temperatures was small (32° F. to 36° F.) and it was difficult to compare small differences in temperature unless much data were collected. Since continuous winter temperatures could not be taken in the study areas due to severe ice conditions, their value cannot be appraised fully.

Surface Ice Cover. Surface ice cover was found to indicate ground water seepage by reflecting the winter water temperature. Those sections of the stream with significant seepage rarely reached 32° F. and rarely froze at the surface. Other sections of the stream with little seepage froze over to some degree. Study Area I rarely showed any ice cover in the two years of observations. Study Area II froze over more completely than Study Area I but less than III or IV. The latter areas froze early and remained covered for a long time after each cold period. Gradient did not appear to affect surface ice formation significantly, because Study Area IV with twice the gradient of any other area had the greatest ice cover.

Aerial photographs of Study Areas II and III, taken January 31, 1952, indicated the great difference in the amount of surface ice between these areas although they were only three miles apart. Aerial photographs in winter were valuable for mapping trout habitat in this stream.

An important limitation is that photographs must be taken during a very cold period. At these periods, local areas with ground water seepage will be free of ice, while nearby areas without seepage will be covered with ice. The method of using winter ice cover to map ground water should be investigated on other streams before it is applied extensively.

Bottom Soil Temperature. Temperatures of the water in bottom soils were used to locate accurately places where ground water was seeping through the stream bed. Portions of the stream bottom with seepage were warmer in winter and cooler in summer than other portions (Figure 3). This method would be difficult to use unless ground water had already been located generally by one of the previously described methods. In this investigation the use of bottom soil temperatures proved valuable to show the importance of ground water for brook trout spawning.

The Importance of Ground Water

Ground water influenced trout populations in the Pigeon River by controlling the location of trout redds. Brook trout spawning was present solely in sections of the stream which showed much ground water seepage; brown trout spawning areas were more widely scattered. The largest number of brown trout redds was, however, concentrated where ground water was present in quantity. Population estimates indicated that the number of trout in a section of stream was directly correlated with the amount of local spawning. Study Area I had a large number of redds (20 to 56) and a large permanent trout population (560 over 4 inches in July 1951); Study Area II had a moderate number of redds (1 to 7) and a moderate trout population (239 over 4 inches in July 1951); Study Areas III and IV had no redds and small trout populations (less than 20 over 4 inches in July 1951).

In addition to ground water, the effect of other ecological factors was considered in the location of brook and brown trout redds. Study areas III and IV had several sections of the channel with suitable gradient, bottom type, and depth for spawning, but these areas were never utilized. White (1930), Hazzard (1932), and Greeley (1932) noted spring water and gravel at the spawning sites of brook trout. On the Pigeon River, the lack of ground water appeared to be the only factor which prevented spawning. Hobbs (1937) mentions that the following conditions are present at brown trout spawning sites in New Zealand: stable bottom, good diatomaceous growth on stones, lack of flooding, and slight gradient. In the Pigeon River, brown trout chose stable bottom materials for nesting. Generally, they spawned in coarse gravel and rubble, often downstream from brook trout redds which were predominantly in finer gravel. In part, this difference in habitat selection between the two species may be due to the fact that brown trout spawn at a larger size (usually above 9 inches) than brook trout (usually above 6 inches) and thus may be able to move larger stones to form redds. A good algal growth (partly diatomaceous) was generally present on the gravel in all study areas. All study areas had adequate gradient for spawning in some portion of the channel. Study Areas II, III, and IV all had adequate spawning sites for brown trout, but redds were observed only in Study Area II, which possessed ground water seepage. Several workers (Hubbs *et al.,* 1932; Davis, 1934; Hazzard, 1937) mention that stream improvement structures tend to expose gravel and increase spawning areas. The evidence in this investigation indicates that ground water seepage is of much more importance than bottom type and should be investigated before environmental improvements of this type are constructed.

Shetter (1937) and Watts *et al.,* (1942) found that brook trout do not migrate significantly throughout their lifetime. Schuck (1945) and Hobbs (1937) found similar results with the brown trout. Due to the lack of extensive migration of both brook and brown trout, the amount of spawning in a section of stream must strongly influence the population at any given site. Hobbs (1937 and 1940) found that brown trout populations in New Zealand corresponded closely with the distribution of redds and that the development of populations had been possible only where satisfactory facilities for natural reproduction existed. Data from the Pigeon River supported this contention for both brook and brown trout. Heavy fishing may reduce the size of the spawning populations (Hobbs, 1937; Cooper, 1951). Although the amount of fishing pressure in the four study areas was only generally known, fishermen were frequently observed in all sections of the stream, and angling cannot be used to account for the extreme differences in fish populations.

APPLICATION TO MANAGEMENT OF TROUT STREAMS

The importance of ground water seepage to trout populations should be considered in environmental improvement of trout streams and in trout stream surveys. In Michigan, two types of trout stream improvement are being pursued currently. The first consists of the construction of various types of midstream cover such as deflectors, rafts, and deep pools and was under way in the 1930's (Hubbs *et al.,* 1932). Work of this type may possibly have an influence on the survival rate or growth rate of trout, but it could not affect natural trout populations unless spawning facilities were first available. The second type of environmental improvement is concerned with the management of the watershed and is a recent development. One of its aims is to divert rainfall into the ground where it may enter the stream as ground water rather than as surface runoff or through tributaries (Tody and Clark, 1951). Any program which would increase ground water flow would be of much value to many sections of the Pigeon River. In many parts of this stream, the lack of ground water appeared to be the only condition which was a limiting factor on trout production. Adequate food and cover and suitable bottom types were all present, but trout populations were still very sparse.

Trout stream surveys of varying degrees of thoroughness are instituted to determine the possible management techniques which can be used in a particular stream. Provided the trout have had an opportunity to inhabit a stream, either naturally or by artificial introduction, the resident fish population is probably the best indicator of the suitability of any habitat for a particular species. In Michigan, Westerman (1926) stated that all stream systems had been planted with brook trout at one time or another. Brown and rainbow trouts had also been planted at various times in most waters. In that state, therefore, it may be assumed that the existing salmonid populations would represent the amount and condition of the trout habitat. Since ground water was found to be basic to trout production in the Pigeon River, some measure of this ecological factor should be made.

Most stream surveys are conducted in summer when weather conditions are most suitable; winter conditions are neglected. In this stream use of aerial photographs to determine the amount of surface ice cover was found to be a practical and accurate method for the locating of ground water seepage and thereby also locating the areas possessing the greatest trout populations. A large section of stream could be photographed in a short period of time and the ground water seepage areas quickly located prior to actual ground investigation. While all types of data can be collected, the aim of a survey should be to determine the ecological factors which are actually limiting trout production. Only after these ecological conditions are determined can management be intelligently and economically applied to correct these deficiencies.

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DISCUSSION

DR. BENNETT: Mr. Benson's paper is open for discussion. Let's hear from some of you trout men.

MR. ALBERT HAZZARD (Michigan): I think there may be a question as to whether ground water has any particular virtue, aside from suitable temperature. In other words, if you could have low temperatures, I am wondering if you would not have just as good trout water as if the water came out of the ground. Of course, the two are usually correlated. I wonder if ground water has some other virtue in making good trout habitat and temperature; or is it temperature, in your opinion?

MR. BENSON: I believe it is mainly temperature. In the Pigeon River, it was ground water; but I know, in Tennessee right now, we have these tail-water streams coming out of these reservoirs, and they have excellent trout populations, although we are not quite positive whether we have much natural reproduction in these areas. In other words, ground water actually controlled the temperature in the Pigeon River, and that was the important factor.

DR. BENNETT: Mr. Benson, may I ask a question? If you have a stream which has become silted up, do you have any suggestions for improving the ground-water flow again?

MR. BENSON: No, I did not attempt to improve ground-water flow at all.

MR. ELKINS (Alaska): Were you able to distinguish between the fast ice-freeze stretches and those where the ground water came up? Did you have any difficulty with that on your photographs?

MR. BENSON: I probably did not make it very clear, but I found that the area with the greatest gradient—there was about 0.3 per cent—had the greatest ice cover. In other words, gradients did not seem to be a limiting factor, as far as surface ice was concerned.

MR. ELKINS: I should think it would.

MR. BENSON: It is possible; that is true.

DR. PETRIDES (Michigan State College): I wonder if you found any correlation between the type of vegetation in the region of the seepage and the occurrence of the seepage itself?

MR. BENSON: I did collect quite a few aquatic plants and I could find no correlation between the abundance of the aquatic plants and the seepage.

Northern white cedar was more common where you would find ground-water seepage into the stream, but that factor could not be utilized very generally. It was a variable proposition. I tested that in several cases, and I would not dare use it as an indicator of trout water.

DR. PETRIDES: I notice that some of the hydrologists report higher ground levels in areas where there is scrubby vegetation or grass vegetation rather than trees growning on the area. I wonder then if that would mean you would have greater possibilities for cool temperatures in streams, at least where you got the shrubbery vegetation or grass vegetation rather than flowers. It is contrary to your usual viewpoint with respect to trout streams. I wonder if you had any observations which we could tie in with the hydrologists' findings.

MR. BENSON: I did not do any work on that, but I know, where you have the top of a hill which is completely devoid of streams, you have less ground water.

AN INTENSIVE CREEL CENSUS ON CLEARWATER LAKE, MISSOURI, DURING ITS FIRST FOUR YEARS OF IMPOUNDMENT, 1949-1952

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With the construction of numerous flood-control reservoirs throughout the country, it is important for management purposes to note the changes in the fishery which occur in the transition from stream to lake. Futhermore, the analysis of trends which develop in the fishing success are of considerable importance. For this reason, the intensive creel census was conducted on Clearwater Lake during the first four years of its impoundment.

Clearwater Lake is located on the Black River in southeastern Missouri. It was constructed and is operated by the U. S. Corps of Engineers as a flood-control reservoir. At conservation pool level it has an area of 1,650 acres and a shoreline of 27 miles. The impounded water extends up the Black River for more than six miles and up Logan Creek, a tributary of Black River, for about half that distance (Figure 1). At flood pool level, the surface area covers over 10,000 acres, and its shoreline is increased to about 172 miles. The dam was completed in 1948 and the lake filled in June of that year.

An intensive creel census was initiated in 1949 under the direction of Dr. Paul H. Eschmeyer[1]. The objectives of the census were to obtain a record of the catch and to compare the species composition in the catch during each year for the several years of impoundment and to measure seasonal fluctuations in species composition during any given year; to derive an estimate of the annual yield of fish to anglers; to measure changes in fishing quality seasonally; to observe any changes in species composition that might occur in the catch in the change from a stream to lake environment; to measure the fishing pressure occurring on the lake. The census was conducted between May 28 and November 30, 1949. It was resumed on May 30, 1950 and continued through November 30 of that year. During the first two years of operation, the creel census was limited to the open season for black bass in Missouri. A year-around fishing season was authorized for certain Missouri waters, including the large artificial impoundments, effective January 1, 1951. In 1951 and 1952 the census period was extended to include the year-around fishing season.

[1]U. S. Fish and Wildlife Service, Ann Arbor, Michigan.

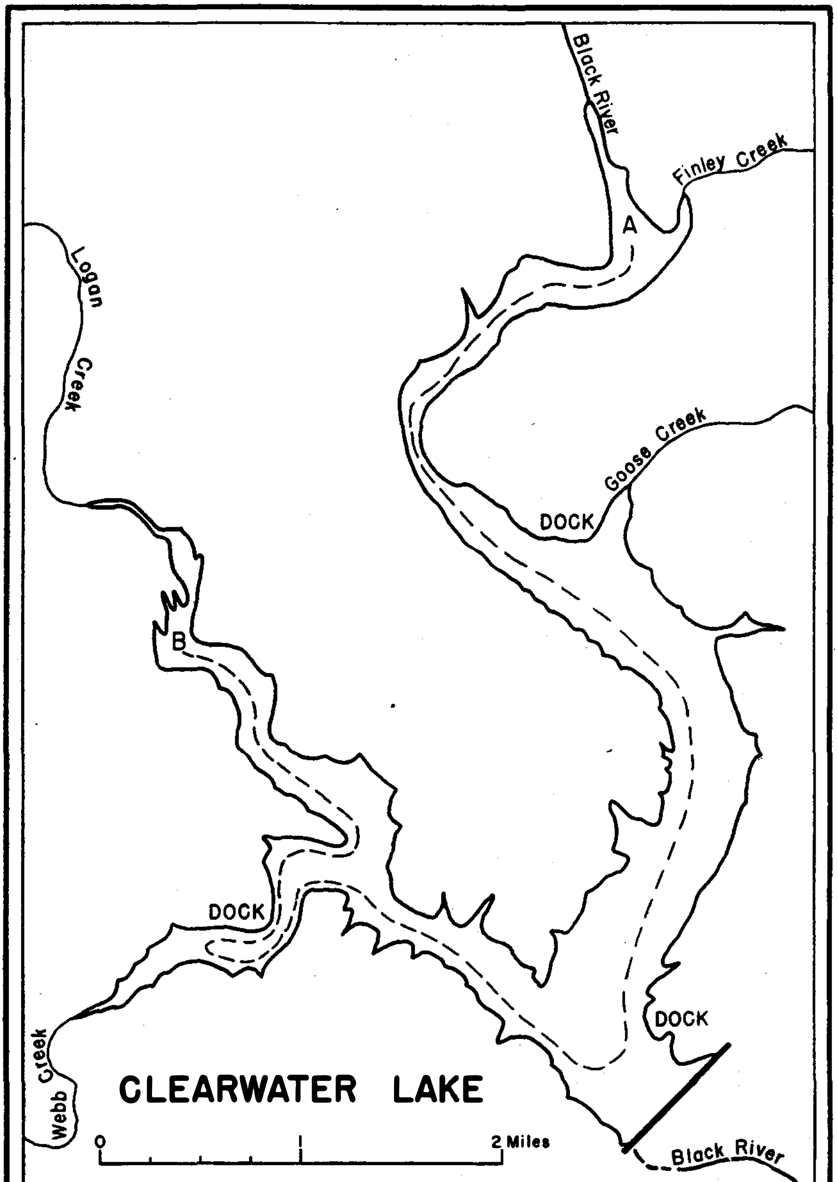

FIGURE 1. CLEARWATER LAKE, SHOWING THE LOCATION OF THE BOAT DOCKS AND THE ROUTE FOLLOWED BY THE CREEL CENSUS CLERK WHILE MAKING HIS FISHERMAN COUNTS.

CREEL CENSUS METHODS

The principal duties of the creel census clerk were to count, according to a pre-arranged schedule, the number of fishermen using the lake and to interview fishermen who had completed their fishing trips. Information collected for each fishing trip included the date, number of fishermen in the party, hours fished, method of fishing, type of bait used, species and number of fish in the catch, estimated average length of each kind of fish taken, and the residence of the anglers. Fish were measured frequently by the clerk to verify the accuracy of his estimates.

There are three commercial docks and several boat-launching areas on the lake. The clerk divided his time among these areas and obtained as many creel census records from anglers as was possible during his working day.

The census was conducted on the basis of an eight-hour work day, five and one-half days a week. The working hours were changed every day according to a pre-arranged schedule. Weekly leave days were changed in a similar manner. If the work day began as early as 6:00 a.m. it lasted until 3:00 p.m. The following day it would begin at 7:00 a.m. and last until 4:00 p.m. Starting times were advanced one hour every day until the work day started at 12:00 noon, after which the starting time at 6:00 a.m. was resumed and the above arrangement repeated. The schedule, of course, varied with the months of the year because of the difference in number of daylight hours.

FISHING SUCCESS

Of an estimated 95,175 fishing trips during the four-year period, 11,387 creel census records were obtained, or 12 per cent of the total. The data were tabulated in quarterly periods in order that they could be compared for the four-year period. The periods were: December, January, and February; March, April, and May; June, July, and August; September, October, and November. These periods are referred to as winter, spring, summer, and fall, respectively. The summer periods in 1949 and 1950 started with the opening of the bass season which was May 28 in 1949 and May 30 in 1950.

A summary of the fishing effort and success of fishermen for the years 1949-1952 is shown in Table 1. During the 1949 season, 2,714 fishermen were interviewed at the completion of their fishing trip. They had fished for 11,368 hours and had taken 7,345 fish. The rate of catch was 0.65 fish per hour, or 2.7 fish per trip.

In 1950, 2,445 anglers were interviewed. They had fished a total of

TABLE 1. NUMBER OF ANGLERS INTERVIEWED, HOURS FISHED, NUMBER OF FISH CAUGHT, AND THE AVERAGE CATCH PER HOUR LISTED BY QUARTERS FOR CLEARWATER LAKE FROM 1949-52.

	Number of anglers interviewed				Hours of fishing				Number of fish caught				Average catch per hour			
	1949	1950	1951	1952	1949	1950	1951	1952	1949	1950	1951	1952	1949	1950	1951	1952
December-February ..			108	85			417	318			79	62			0.19	0.19
March-May			950	999			5,205	6,518			3,558	2,640			0.68	0.41
June-August	1,687	1,389	1,525	1,172	7,131	7,199	7,813	5,965	4,616	4,153	3,635	1,755	0.65	0.58	0.47	0.29
September-November ..	1,027	1,056	775	614	4,237	5,611	3,660	3,092	2,729	2,230	1,062	957	0.64	0.40	0.29	0.31
Total	2,714	2,445	3,358	2,870	11,368	12,810	17,095	15,893	7,345	6,383	8,334	5,414	0.65	0.50	0.49	0.34

12,810 hours, and succeeded in taking 6,383 fish. This was at the rate of 0.50 fish per hour, or 2.6 fish per trip.

A total of 3,358 fishermen were interviewed in 1951. This was the first year fishing was permitted throughout the year for all species. These anglers fished for 17,095 hours and took 8,334 fish. This amounted to a rate of 0.49 fish per hour, or 2.5 fish per trip.

A total of 2,870 anglers were interviewed in 1952. They fished 15,893 hours, and caught 5,414 fish, at a rate of 0.34 fish per hour, or 1.9 fish per trip.

The rate of success was nearly the same in the summer and fall of 1949 and the spring of 1951. Fishing success was quite low in the summer of 1951 and in the summer and fall of 1952. It was lowest during the winters of 1951 and 1952. A decline in the average catch per hour occurred during the four-year census period. The average rate of catch declined from 0.65 fish per hour in 1949 to 0.34 fish per hour in 1952.

Shore fishermen were very much in the minority during the entire census period. They made up only 10.4 per cent of the fishermen counted. They had better than average fishing success all four years. However, the fish they caught were mostly the smaller pan fishes and bullheads. They took very few black bass.

Still fishing with live bait was the most frequently used method of fishing reported in the census. Artificial-bait fishermen recorded only 17 per cent of the total fishing hours. Yet, fifty per cent of the catch of artificial-bait fishermen was made up of black bass, and in 1951 and 1952, they took more than half of all the black bass creeled.

SPECIES IN THE CATCH

Nineteen species were represented in the creel during four years of censusing (Table 2). Of these, crappies, bluegills, bullheads, and largemouth black bass were the most important species represented in the creel. Yellow and black bullheads, and black and white crappies are present in the lake, but yellow bullheads and black crappies are so few that no attempt was made to differentiate between the two kinds of bullheads or crappies.

During each of the four years of impoundment, there were several changes in relative abundance of different species in the catch. The upper Black River is considered one of the finer smallmouth black bass streams in Missouri. This is confirmed by information from a creel census conducted throughout the fishing seasons during the five-year period 1946-1950. Smallmouth black bass averaged 30 per cent of the catch from the upper Black River during the census period.

TABLE 2. THE NUMBER AND PERCENTAGE IN THE CATCH OF THE FISH COUNTED IN THE CREEL FROM CLEARWATER LAKE DURING 1949-1952.

	1949		1950		1951		1952	
	No.	% of catch	No.	% of catch	No.	% of catch	No.	% of catch
Largemouth black bass	1,876	25.5	1,570	24.6	621	7.5	565	10.4
Bluegill	1,717	23.4	1,865	29.2	2,104	25.2	1,559	28.8
Crappie (white and black)	981	13.4	1,832	28.7	4,290	51.5	2,456	45.4
Longear sunfish	934	12.7	45	0.7	27	0.3	1	Tr[1]
Green sunfish	644	8.8	98	1.5	2	Tr	109	2.0
Bullhead (yellow and black)	482	6.6	738	11.6	1,218	14.6	661	12.2
Smallmouth black bass	391	5.3	83	1.3	17	0.2	28	0.5
Rock bass	222	3.0	150	2.3	37	0.4	6	0.1
Warmouth	84	1.1	1	Tr	....	....	....	....
Flathead catfish	4	0.1	1	Tr	....	....	....	....
Common shiner	4	0.1	....	....	....	....	....	....
Carp	2	Tr	....	....	17	0.2	14	0.3
Channel catfish	2	Tr	....	....	....	....	7	0.1
Yellow walleye	1	Tr	....	....	....	....	....	....
Spotted sunfish	1	Tr	....	....	....	....	....	....
Grass pickerel	....	....	....	....	1	Tr	....	....
Redhorse spp.	....	....	....	....	....	....	8	0.1
Total	7,345	100.0	6,383	100.0	8,334	100.0	5,414	100.0

[1]Tr—less than 0.1 per cent.

However, this species has almost disappeared from the Clearwater Lake creel since impoundment. It made up 5.3 per cent of the catch in 1949, 1.3 per cent in 1950, 0.2 per cent in 1951, and 0.5 per cent in 1952.

Suckers, predominantly golden redhorse, black redhorse, and hog suckers, ranked second in the creel of the upper Black River. However, they did not appear in the Clearwater creel before 1952, and then made up only 0.1 per cent of the catch. Golden and black redhorse are fairly abundant in the lake. This was determined from population studies conducted by Commission biologists. They are not sought by lake fishermen and for this reason are of little importance in the Clearwater Lake creel.

Rock bass made up 19 per cent of the upper Black River creel. They comprised 3 per cent of the Clearwater creel in 1949. A slight decline was noted in 1950, and in 1952 they made up only 0.1 per cent of the creel.

Longear sunfish made up 14 per cent of the Black River creel. In the Clearwater creel in 1949, they comprised 12.7 per cent of the catch. However, a marked decline occurred in the lake in 1950 when they made only 0.7 per cent of the catch. They showed a further decline in 1951. In 1952 only one longear sunfish was reported in the creel.

Largemouth black bass were not as numerous in the Black River creel as smallmouth black bass. In fact, they made only 7 per cent of the river creel. During the first year of the census on the lake largemouth black bass made up 25.5 per cent of the catch. A decline of about one per cent was noted in 1950. In 1951 largemouth black bass decreased to 7.5 per cent of the catch. However, part of this decrease was regained in 1952 when they made up 10.4 per cent of the creel. Although an increase was noted in the percentage of largemouth black bass in the 1952 catch, the number creeled was less than in 1951. This was probably due to the lower rate of fishing success in 1952. The same was true in the catch of bluegills. The average length of largemouth black bass in the catch increased from 9.5 inches in 1949 to 12.4 inches in 1952.

There was little difference in the numbers of largemouth black bass caught during the summer and fall in 1949. Fifty-two per cent of all largemouth black bass creeled were caught in the summer and 43 per cent in the fall. Of those caught in the summer 38 per cent were taken during the first four days of the bass season. In 1950, 87 per cent of all the largemouth black bass were harvested in the summer and only 13 per cent in the fall. The large percentage of bass harvested during the first few days of the open season in 1949 did not occur in 1950. In 1951, 47 per cent of the largemouth black bass were harvested in the spring and almost 46 per cent in the summer. Seven per cent were taken in the fall and less than one per cent in the winter. In 1952 spring fishing produced 65 per cent of the largemouth followed by 20 per cent for the summer and 13 per cent for the fall. Again, only a few were caught in the winter. With a closed season the percentage of largemouth black bass in the catch would no doubt have been considerably lower than it was in 1951 and 1952.

Crappies showed the greatest increase in the catch during the four years, both by number and per cent. They comprised 13.4 per cent of the catch in 1949; 28.7 per cent in 1950; 51.5 per cent in 1951, and 45.4 per cent in 1952. They made up only 0.1 per cent of the upper Black River creel between 1946 and 1950. A consistent increase in the average length of crappies was observed during the first three years of the census. A slight decline was noted in 1952.

Crappy fishing was best in the spring of 1951 and 1952 when 58 and 57 per cent, respectively, of all crappies were taken. The census was not conducted in the spring in 1949 or 1950. However, anglers caught 59 per cent of the crappies during the fall season of 1949 and 67 per cent during the fall in 1950. This suggests that crappie fishing was best when weather temperatures were cool. About one-third of the crappies were taken in the summer season in 1949, 1950, and 1951, but in 1952 only 14 per cent were caught during this season. The winter fishing seasons produced very few crappies in 1951 and 1952.

Bluegills have shown the least variation in percentage of the catch of any of the four principal species represented in the creel. They made up 23.4 per cent of the catch in 1949, 29.2 per cent in 1950, 25.2 per cent in 1951, and 28.8 per cent in 1952. The average length of bluegills taken also varied little in the four years.

The largest percentage of bluegills was harvested during the summer in all four years. In 1949, 72 per cent were taken in the summer; 71 per cent in the summer of 1950; 60 per cent in the summer of 1951; 58 per cent in the summer of 1952. Bluegill fishing was next best in the spring of 1951 and 1952. Bluegills consistently sustained fishing success during the summer period throughout the four-year census.

Although bullheads are not classified as game fish in Missouri, they are important in the Clearwater fishery, and seem well adapted to the impoundment. They made up only 1.4 per cent of the upper Black River creel 1946-50, whereas they comprised 6.6 per cent of the lake creel in 1949, 11.6 per cent in 1950, 14.6 per cent in 1951, and 12.2 per cent in 1952. Bullheads have shown a consistent increase in average length throughout the census period. Summer fishing produced the most bullheads to anglers.

Green sunfish, which made up 4.5 per cent of the 1946-50 upper Black River creel, comprised 8.8 per cent of the 1949 creel of Clearwater Lake. However, in 1950 they dropped to 1.5 per cent of the lake creel. In 1951 only two green sunfish were reported caught, but in 1952 they made up 2.0 per cent of the catch. Several other species were reported in the creel, but were of little importance numerically.

FISHING INTENSITY

The methods used to determine fishing intensity are similar to those described by Eschmeyer (1942), and Tarzwell and Miller (1942). The counts of fishermen were made from a boat driven at maximum speed with a 10-horsepower outboard motor between the two extremities of the impoundment (points A and B in Figure 1). The hours at which counts of fishermen were made were changed daily. Morning and afternoon counts were made. The afternoon count was made in the opposite direction of the morning count and the morning counts were made in the opposite direction each day. The number of counts made each day of the week is shown in Table 3. Although the number of counts was not the same for every day of the week, the distribution is spread sufficiently so that the average number of fishermen counted per day is not distorted by heavy intensity on week ends or holidays. In making the count the clerk recorded the number

TABLE 3. NUMBER OF COUNTS OF FISHERMEN MADE AT CLEARWATER LAKE DURING THE 1949-1952 CENSUS PERIODS.

	1949	1950	1951	1952
Sunday	42	38	60	74
Monday	44	36	60	67
Tuesday	41	33	60	70
Wednesday	39	28	62	67
Thursday	42	26	61	66
Friday	41	31	60	72
Saturday	46	37	63	67
Totals	295	229	426	483

of fishermen seen, tabulating separately those fishing from shore and those fishing from boats.

The number of counts made, number of boat and shore fishermen counted, and the average number of fishermen counted per day during the four years of the census are shown in Table 4. An average of 30 fishermen used the lake daily in 1949; 41 in 1950; 42 in 1951; 32 in 1952. Fishing intensity was greatest during the summer in all years except 1952, when it was greatest in the spring. Very little fishing was done during the winters of 1951 and 1952, the only two winters during which the census was made. Fishing pressure increased considerably during the first three years of the census. A decline occurred in 1952. The average number of fishermen using the lake each day does not clearly show the large increase in fishing intensity that actually occurred over the four-year period of the census. The average includes those periods, particularly during the winter of 1951 and 1952 when very few fishermen were using the lake and this lowers the average number per day. However, it does not affect the estimated total number of fishing trips as that total is an accumulation of the totals for each fishing period. The actual number of fishermen counted clearly shows the increase in the number of anglers using the lake between 1949 and 1952. The increase in 1951 and 1952 is largely attributed to the spring fishing season which was not included in 1949 and 1950.

With one exception, the estimated number of fisherman days was determined as outlined by Eschmeyer (1942), and Tarzwell and Miller (1942). They determined the daily number of fishing trips by doubling the boat count. On Clearwater Lake it is believed that a more accurate estimate of the number of fishing trips could be made by obtaining a daily turnover, using the average time per fishing trip and the average length of the census day. Considerable early morning and evening fishing is done on Clearwater Lake. It was not believed that the eight-hour day would give a sufficiently accurate picture of the number of fishermen actually using the lake each day. For this rea-

TABLE 4. NUMBER OF COUNTS OF FISHERMEN, BOAT AND SHORE FISHERMEN COUNTED, THE AVERAGE DAILY NUMBER OF ANGLERS, AND THE PER CENT OF BOAT FISHERMEN TABULATED BY QUARTER IN THE CREEL CENSUS—CLEARWATER RESERVOIR, 1949-52.

	Number of counts				Boat fishermen				Shore fishermen				Average number per day				Percentage of boat fishermen			
	1949	1950	1951	1952	1949	1950	1951	1952	1949	1950	1951	1952	1949	1950	1951	1952	1949	1950	1951	1952
Dec.-Feb.			71	92			82	59			35	7			1.6	0.7			70.1	89.4
March-May			102	130			5,617	7,028			961	388			64	57			85.4	94.8
June-Aug.	148	103	118	136	5,030	5,104	7,297	5,039	1,372	606	825	274	43	55	69	39	78.6	89.4	79.8	94.8
Sept.-Nov.	147	126	135	125	2,122	3,348	3,028	2,620	300	281	223	138	16	29	24	22	87.6	92.3	93.1	95.0
Total or Ave.	295	229	426	483	7,152	8,452	16,024	14,746	1,672	887	2,044	807	30	41	42	32	81.1	90.5	88.7	94.8

son, the fishing day was considered to extend from one-half hour after sunrise to one-half hour after sunset in computing the average daily turnover of fishermen. The daily turnover of fishermen was computed by dividing the average length of the census day by the average time fished. The daily turnover was then multiplied by the average number of fishermen counted to determine the fisherman days per calendar day.

The total number of fishing hours was computed by multiplying the fisherman days by the average time fished per trip. The total number of fishing hours multiplied by the average rate of success gave the total estimated catch.

Table 5 shows the estimated number of fishing trips, fishing hours, number of fish caught, number of trips per acre, number of fishing hours per acre, and the number of fish caught per acre. It was estimated that there were 17,400 fisherman days of effort applied to the lake in 1949, 19,225 in 1950, 35,450 in 1951, and 23,100 in 1952. This involved 72,725, 99,175, 183,550, and 130,275 fishing hours, respectively, in each of the four years enumerated above.

The fishing effort in 1949 was 44.1 hours per acre, or about 10.5 fisherman days per acre; 60.1 hours, or 11.7 fisherman days per acre in 1950; 111.2 hours, or 21.5 fisherman days per acre in 1951; 79 hours, or 14.0 fisherman days per acre in 1952. Fishing intensity, insofar as it concerned the number of fisherman days per acre, was greatest in the summer all four years. However, there were more fishing hours per acre expended in the springs of 1951 and 1952. This was due to the increased length of the individual fishing trips. Fishing intensity was very low in the winter, and a large decline occurred between the summer and fall seasons all four years.

ESTIMATE OF HARVEST

The total catch was estimated to be 47,125 fish in 1949, 51,775 in 1950, 96,625 in 1951, and 45,450 in 1952—a consistent increase in the number caught during the first three years of the census followed by a large decline in 1952. Increased fishing intensity in 1951, and an increasing population of certain species of fish in the lake, was undoubtedly responsible for the large increase in total catch that year over the two preceding years. The decline in total catch in 1952 resulted from the decrease in fishing success and a decline in fishing intensity. In 1949, 62 per cent of the fish creeled were taken during the summer. In 1950, 15 per cent were creeled in the same period. Forty-three per cent of the catch in 1951 was caught in the spring and 49 per cent was taken in the spring of 1952. Only 0.2 per cent of the catch was made in the winters of 1951 and 1952.

TABLE 5. THE ESTIMATED TOTAL NUMBER AND NUMBER PER ACRE OF FISHING DAYS AND HOURS OF FISHING ON CLEARWATER LAKE IN 1949-1952, TOGETHER WITH AN ESTIMATE OF THE TOTAL NUMBER AND NUMBER PER ACRE OF FISH CAUGHT. THESE DATA ARE PRESENTED FOR EACH QUARTERLY PERIOD.

		Estimated number of fisherman days	Estimated number of fishing hours	Estimated number of fish caught	Per cent of catch	Fishermen days per acre	Number of fishing hours per acre	Number of fish caught per acre
Dec.-Feb.	1951	325	1,300	250	0.2	0.2	0.8	0.2
	1952	150	575	100	0.2	0.1	0.3	0.1
Mar.-May	1951	12,950	71,250	48,450	50.2	7.8	43.2	29.4
	1952	9,450	61,350	25,150	55.3	5.7	37.2	15.2
June-Aug.	1949	13,625	57,200	37,200	78.9	8.3	34.7	22.5
	1950	13,950	71,200	40,575	78.4	8.5	43.2	24.6
	1951	17,150	87,400	41,075	42.5	10.4	53.0	24.9
	1952	9,700	49,400	14,325	31.5	5.9	29.9	8.7
Sept.-Nov.	1949	3,775	15,525	9,925	21.1	2.3	9.4	6.0
	1950	5,275	27,975	11,200	21.6	3.2	17.0	6.8
	1951	5,025	23,600	6,850	7.1	3.0	14.3	4.2
	1952	3,800	18,950	5,875	12.9	2.3	11.5	3.6
Total	1949	17,400	72,725	47,125	....	10.5	44.1	28.6
	1950	19,225	99,175	51,775	....	11.7	60.1	31.4
	1951	35,450	183,550	96,625	....	21.5	111.2	58.6
	1952	23,100	130,275	45,450	....	14.0	79.0	27.5

The estimated catch by species is shown in Table 6. These values were computed by applying the per cent of the total yield, for each species in the creel, to the total estimated yield (Table 5). The values were rounded off to the nearest twenty-five. Considerable fluctuation in number of fish caught has occurred during the four years of the census.

Fish were creeled at the rate of 28.6, 31.4, 58.6, and 27.5 per acre, respectively, in 1949, 1950, 1951, and 1952. More fish per acre were caught in the spring of 1951 than during any other period of the census. The number of fish caught per acre during the summer showed little change between 1949 and 1951. A marked decline was evident

TABLE 6. SPECIES AND ESTIMATED NUMBER OF FISH TAKEN BY ANGLERS FROM CLEARWATER LAKE, 1949-1952.

Species	Estimated numbers caught 1949	1950	1951	1952
Largemouth black bass	12,025	12,750	7,250	4,725
Bluegill	11,025	15,125	24,350	13,100
Crappie	6,325	14,850	49,750	20,650
Longear sunfish	5,975	350	300	......
Green sunfish	4,150	775	......	900
Bullhead	3,100	6,000	14,100	5,550
Smallmouth black bass	2,500	675	200	225
Rock bass	1,400	1,200	375	......
Warmouth	525	......	......	......
Carp	......	......	200	125
Other species	100[1]	50[2]	100[3]	175[4]
Total	47,125	51,775	96,625	45,450

[1]Flathead catfish, channel catfish, carp, yellow walleye, spotted sunfish, common shiner.
[2]Carp, warmouth.
[3]Green sunfish, grass pickerel.
[4]Channel catfish, rock bass, redhorse spp., longear sunfish.

in the summer of 1952. Only 0.2 and 0.1 fish per acre respectively were creeled in winters of 1951 and 1952.

No weights were recorded by the creel census clerk. However, the length-weight relationships for the various species in Clearwater Lake have been determined in other studies on this reservoir. These weights were used to compute the weight of the catch. Based on these figures, the estimated catch was 11,300 pounds, or 6.8 pounds per acre in 1949; 17,200 pounds, or 10.4 pounds per acre in 1950; 51,600 pounds, or 31.3 pounds per acre in 1951; 25,200 pounds, or 15.2 pounds per acre in 1952. The increase in 1951 can be attributed, for the most part, to increased fishing intensity resulting from the extended fishing season. The increase in the average size of the fish creeled each year together with a change in the species composition contributed to the heavier catch. This was very evident in 1952: the yield was less than in 1949, but, because larger fish were caught, the production in pounds per acre was more than doubled.

SUMMARY

1. The creel census was conducted between 1949 and 1952, the first four years after Clearwater Lake was impounded.

2. A total of 11,387 creel census records were obtained during the census. The average catch per hour declined from 0.65 fish per hour in 1949 to 0.34 fish per hour in 1952.

3. There were changes in relative abundance of different species in the catch during each of the four years of the census. Crappies, bluegills, largemouth black bass, and bullheads were the four principal species in the creel.

4. Smallmouth black bass have practically disappeared from the Clearwater creel as have longear sunfish and rock bass. These three species plus suckers are important in the fishery of the upper Black River. Only eight suckers have been recorded in the creel from Clearwater Reservoir.

5. Fisherman counts showed an average of 30 fishermen per day in 1949; 41 in 1950; 42 in 1951; 32 in 1952.

6. Fishing intensity was greatest during the summer period in all years except in 1952. In 1952 it was greatest in the spring.

7. An estimated 95,175 fisherman days of effort were expended on the lake during the four-year census.

8. The total catch was estimated at 47,125 fish in 1949, 51,775 in 1950, 96,625 in 1951, and 45,450 in 1952.

9. About 78 per cent of the year's harvest was in the summer in 1949 and in 1950. In 1951 and 1952, when the census was conducted

all year, 50 and 55 per cent of the catch, respectively, was taken in the spring.

10. Fish were taken at the rate of 6.8 pounds per acre in 1949, 10.4 in 1950, 31.3 in 1951, and 15.2 pounds per acre in 1952.

11. In general, the average lengths for all species of fish in the creel increased during the four years.

ACKNOWLEDGMENTS

The investigation was originally planned and put into operation by Dr. Paul H. Eschmeyer. The U. S. Corps of Engineers has provided their fullest cooperation throughout the entire study. I wish to thank Mr. P. G. Barnickol, Mercer Patriarche and John Funk for their valuable assistance in preparation of the manuscript. I also wish to thank Mr. Werner O. Nagel for his technical assistance in preparation of the paper. Special credit is due the creel census clerks, especially Charles H. Anderson and Louis F. Newhouse, who were very efficient in obtaining creel census from the many fishermen using the lake.

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DISCUSSION

DR. BENNETT: This paper is now open for discussion. I would like to ask Mr. Kathrein whether he believes the lake is going into a fishing cycle which may be characteristic of some of the other reservoirs in Missouri. Would you want to comment on that, Mr. Kathrein?

MR. KATHREIN: It is a good question. The cycle of artificial impoundment was thought to be somewhat different than this one. Generally good fishing for several years followed impoundment, followed by a decline. But this one was just a steady decline for four years. That is upsetting all previous cycles which were thought to be true.

MR. RICHARD STROUD (Massachusetts): Mr. Kathrein, I think you indicated that summer fishing improved over previous years after the institution of spring fishing. Did I interpret your remarks correctly?

MR. KATHREIN: In summer fishing, the catch per hour declined slightly. Fishing pressure was almost the same in the summer as it was in the spring.

MR. STROUD: Did the summer fishing improve after the institution of spring fishing? I mean as compared with the previous years.

MR. KATHREIN: No, there has just been a general decline throughout the season for both years, after the season was extended.

MR. STROUD: I misunderstood you. Thank you.

POLLUTION CONTROL IN WISCONSIN

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This paper reviews the 27 years of Wisconsin's fight against the pollution of its surface waters, the official thinking regarding pollution and its control as expressed in the basic principles and policies laid down in an early report, and the effect this report has had on subsequent action by the state legislature and its executive agencies.

It describes the types of pollution Wisconsin has to contend with, discusses the salient points of the present anti-pollution statutes, the organization, operation and financing of the "Committee on Water Pollution," and its accomplishments in stemming the tide of pollutional loads on their way to Wisconsin waters.

If you look at the hydrographic map of Wisconsin, you will see a veritable network of veins that reaches into every part of the state. Through these veins pulses the life blood of the land, the water. Integrated into this network of streams are most of the numerous lakes which are scattered throughout the glaciated areas of the state.

While the surface waters of Wisconsin are one of the main supports of steadily growing recreational activities, they also play an important part in the development and maintenance of many of our communities and industries.

Unfortunately, such industries and communities have not always recognized their obligations towards the waters they use.

The great mass of the people never realized that the assets they had in their surface waters were being rapidly devaluated, that untreated sewage and industrial wastes were heedlessly dumped into them and created conditions dangerous to human health, destructive to the waters' biota, and offensive from the standpoint of esthetics.

It took a few farsighted and courageous men, supported by the few organizations that believe in basic conservation, to get things moving in the right direction, to put effective anti-pollution legislation on the statute books and to improve this legislation as time went on.

Pollution, according to the existing Wisconsin laws, means: "contaminating or rendering unclean or impure the waters of the state, or making the same injurious to public health, harmful for commercial or recreational use, or deleterious to fish, bird, animal or plant life."

TYPES OF POLLUTIONAL SUBSTANCES

The types of pollutional substances Wisconsin has to contend with may be listed according to the law as follows:

1. Sewage.
2. Industrial wastes, which include liquids or other wastes resulting from any process of industry, manufacture, trade or business or the development of any natural resource.
3. Other wastes, which include all other substances which pollute any of the surface waters of the state.

The discharge of raw or unsatisfactorily treated sewage is objectionable principally from the aspect of public health, but there are other considerations.

The discharge of untreated, insufficiently treated or toxic industrial wastes is objectionable from the aspect of the well-being or even survival of the biota of our surface waters, although, as in the case of sewage, there are other considerations, especially from the esthetic viewpoint.

Industrial wastes may be classified as follows:

1. Concentrated wastes which cannot be satisfactorily treated in conventional type treatment plants and from which useful materials can be obtained.
2. Process wastes or washings which are amenable to treatment by currently known waste disposal processes.
3. Clear, cooling waters or waters containing wastes in low concentration, the discharge of which to streams or lakes will not cause objectionable conditions.
4. Wastes having an adverse effect on fish or other aquatic life due to toxicity or chemical content for which practical treatment processes are not available and disposal of which must be accomplished by means other than discharge to streams.

Wastes may also be divided into such as affect the surface of the water, permeate it, or sink to the bottom.

The surface may be affected by greases, oils, floating solids in raw wastes or rising bottom material.

The water-permeating wastes may be poisons, hot waters, suspended or dissolved solids or bacteria-carrying wastes.

Suspended solids may be of an inorganic or organic nature. The organic substances constitute food for bacteria and may create a biochemical oxygen demand or encourage the production of gases such as hydrogen sulphite deleterious to the biota of the water. Dissolved solids may change the pH or the osmotic pressure also to the detriment of the water's biota.

The bottom of the water may be affected by what is referred to as settleable solids of either an inorganic or organic nature, such as sand, silt, clay, mine waste, on the one hand, and fibers, wood waste, cheese curd and canning solids on the other. Such settleable solids may destroy valuable fish spawning grounds and bottom vegetation.

Industrial wastes such as described above and, to a lesser degree, untreated or unsatisfactorily treated sewage are still being discharged into Wisconsin waters. Nevertheless, the speed with which improvements have been made in the past three years is encouraging evidence of the present law's effectiveness and practicability and the Committee's successful application of the respective statutes.

THE COMMITTEE ON WATER POLLUTION AND ITS PROGRAM

Before 1925 no organized effort was put forth to alleviate pollution of Wisconsin waters.

For the biennium of 1925 to 1927, a sum of $10,000 was appropriated from conservation funds for water pollution control "to be expended in cooperation with the State Board of Health in a manner to be agreed upon by the Conservation Commission and the state health officer."

In 1927, the legislature created the Committee on Water Pollution, consisting of the state chief engineer, a member or other representative of the Public Service Commission designated by the Commission, a conservation commissioner or an employe designated by the Conservation Commission, the state health officer, or a member of the Board of Health, designated by the Board, and the state sanitary engineer, or other engineer appointed by the State Board of Health. It was provided with the powers it substantially has today. Under this act it was the responsibility of the Board of Health, which was represented on the Committee, to appoint one of its representatives as secretary and executive officer. This job was assigned to the state sanitary engineer.

The revision of the 1927 Act by the 1949 legislature recognized the need for a full-time administrative officer and authorized the appointment of a director. At the same time there was authorized an appropriation to the Committee from the general fund a sum of $50,000 for the first year, and $75,000 for each succeeding year. Half of this money was to be transferred from the conservation fund.

To abate and, if possible, to eliminate pollution of our streams and lakes, the Committee on Water Pollution was given certain powers, jurisdiction and authority.

Its foremost responsibility is to "exercise general supervision over the administration and enforcement of all laws relating to the pollution of surface waters of the State," and "to study and investigate all problems connected with the pollution of the surface waters of the State and its control and to make reports and recommendations thereon."

It further has authority:

"To conduct scientific experiments, investigations and research to discover economical and practicable methods for the elimination, disposal or treatmentof industrial wastes to control pollution of the surface waters of the State. To this end the Committee may cooperate with any public or private agency, when requested by such agency, in the conduct of such experiments, investigations and research and may receive on behalf of the State any money which any such agency may contribute as its share of the cost under such cooperative arangements.

"To supervise chemical treatment of waters for the suppression of algae, aquatic weeds, swimmer's itch and other nuisance-producing plants and organisms.

"To issue general orders, and adopt rules and regulations applicable throughout the State for the installation, use and operation of practicable and available systems, methods and means for controlling the pollution of the surface waters of the State through industrial wastes, refuse and other wastes.

"To issue special orders directing particular owners to secure such operating results toward the control of pollution of the surface waters as the Committee may prescribe, within a specified time.

"To make investigations and inspections to insure compliance with any general or special orders, rules and regulations which it may issue.

"To enter into agreements with the responsible authorities of other states, subject to approval by the governor, relative to methods, means and measures to be employed to control pollution of any interstate streams and other waters and to carry out such agreements by appropriate general and special orders.

"In addition to all other powers and duties of the Committee on Water Pollution, it shall have the power and it shall be its duty to hold a public hearing relating to alleged water pollution upon the verified complaint of six or more citizens filed with the Committee."

The provisions of the section of the statutes relating to the Committee on Water Pollution do not abrogate the duties and the powers of the State Board of Health regarding sewage and refuse disposal, but the State Board of Health and the Committee on Water Pollution may act jointly as to all matters which in any way come within the jurisdiction of either or both agencies under the statute which created them.

Certain anti-pollution provisions of the conservation laws have remained in force as a complement to the general anti-pollution statutes as applied and enforced by the State Board of Health and the Committee on Water Pollution. This section of the conservation laws provides:

> "No person shall cast, deposit, or throw overboard from any boat, vessel or other craft into any waters within the jurisdiction of the State, or deposit or leave upon the ice thereof until it melts, any fish offal; or throw or deposit, or permit to be thrown or deposited, into any waters within the jurisdiction of the State any lime, tanbark, ship ballast, stone, sand, slabs, decayed wood, sawdust, sawmill refuse, planing mill shavings, or any acids or chemicals or waste or refuse arising from the manufacture of any article of commerce, or any other substance deleterious to fish life other than authorized drainage and sewage from municipalities and industrial or other wastes discharged from mines, or commercial, or industrial, or ore processing plants, or operations, through treatment and disposal facilities installed and operated in accordance with plans submitted to and approved by the Committee on Water Pollution under Chapter 144, or in compliance with orders of that Committee. Any such order shall be subject to modification by subsequent orders."

Before the 1949 Act went into effect the Committee on Water Pollution did the best it could with limited appropriations and voluntary contributions from industry as authorized by statute, using primarily personnel attached to the Board of Health.

The handicaps it worked under notwithstanding, the Committee accomplished much between 1927 and 1949.

The appointment of a full-time administrative head and a more liberal appropriation resulting from the 1949 legislation enabled the Committee to organize its own office and field force. Outside of the director, the office force consists of four enginers who compile basic information, organize stream surveys, handle industrial waste surveys and matters of research on methods of treating industrial wastes, a chemist who cooperates with the State Laboratory of Hygiene, and a biologist who directs biological surveys and carries out the Committee's aquatic nuisance control program.

The states' principal drainage areas have been blocked into four operational units under a drainage basin engineer for each unit. This organizational setup brings the Committee into more immediate contact with the local pollution problems, makes for speedier detection of violations and more readily available assistance to those who want to comply with the law but have difficulty in doing so because of technical difficulties or ignorance of available pollution abatement methods.

Personnel of the Conservation Department, such as wardens and fisheries biologists, assist in detection and gathering evidence.

The state agencies charged with pollution control have from the very beginning made sincere efforts to carry out their duties with thoroughness and all possible dispatch.

The early official thinking regarding pollution and its control is expressed in the policies and basic principles enunciated in "Stream Pollution in Wisconsin—Special Report—A Joint Report of the Conservation Commission and State Board of Health of Wisconsin Concerning Activities in the Control of Stream Pollution, From July 1, 1925, to December 31, 1926," published in January 1927.

The report declared that it was "impractical to attempt general constructive work on all classes of waste and all streams of the State. It was, therefore, decided to concentrate upon two types of industrial waeste; namely, Pea Cannery Wastes and Paper Mill Wastes, which constitute two of the major sources of pollution in Wisconsin streams."

The report makes reference to a serious pollution condition in the Flambeau River below Park Falls in the late summer of 1925 which killed from 25 to 30 tons of fish and which was traced to wastes from a paper mill. Although this pollution was unquestionably a violation of one of the Wisconsin anti-pollution statutes, says the report, it was recognized "that there was no other known economical and practical method of disposing of these paper mill wastes than then in use." A recommendation was therefore made "that the pulp and paper industry organize the various units of the industry for the purpose of inaugurating and maintaining a sustained, systematic, and scientific search for the solution of the problem of the disposal of the waste materials from the pulp and paper mills, in cooperation with such state and federal agencies as may be available."

A similar suggestion was made to the Wisconsin Canners Association.

Both suggestions were acted upon. The pulp and paper industry is still engaged in extensive research work regarding the disposal of sulphite liquor, including the study of methods developed in foreign countries. If sulphite liquor ceases to be a major problem, as it is expected to do within a very short time, the men who first made the suggestion that the pulp and paper industry study their pollution problems scientifically deserve considerable credit for the outcome.

With reference to municipal wastes, the joint report mentioned above charges the cities and villages with the responsibility for the maintenance of proper sanitary conditions within the areas of their jurisdiction. Unless the volume is excessive, the report says, all industrial wastes of a pollutional nature should be discharged into the public sewerage system. As many industrial wastes interfere with the normal operation of municipal sewage disposal plants, the report further states, preliminary treatment is necessary and cooperation on behalf of both the municipality and the industry is a primary requirement.

Under "Basic Principles" the report asserted that stream pollution may or may not affect the public health, that the greatest danger to public health is from domestic sewage, that such pollution, however, is significant in regard to public health only where the stream is used as a public water supply or for bathing purposes.

References are made also to the detrimental and destructive effect of pollution on aquatic animal and plant life, and to the oxygen-demanding character of nearly all wastes.

It would lead us too far afield to follow step by step the progress that has been made in the various Wisconsin drainage basins in alignment with the above-cited policies and basic principles, but I shall give here a brief picture of how the Committee on Water Pollution in conjunction with the Board of Health operates today and what the results have been up to January 1, 1953.

The Committee does its work on a watershed basis. For its purposes it has divided the state into four work areas covering all 28 major drainage basins. Each area consists of several drainage basins and is under the supervision of a drainage basin engineer who, jointly with the respective district engineer of the Board of Health, makes the necessary surveys to establish points, causes and degree of pollution and makes recommendations regarding abatement.

Hearings are held usually as soon as all the information pertaining to a given watershed has been gathered and prepared for testimony. The Committee invites every polluting industry or community to attend the hearing, listen to the testimony and recommendations of the engineers of the Committee and Board of Health, give their own testimony and their reaction to the official recommendations and state their position as to compliance.

There was a time not many years ago when some of the big polluters especially expended considerable effort to get out from under, appeared at the hearings with batteries of top-grade attorneys, entered voluminous testimony and lengthy briefs and obviously employed delaying tactics.

Today, the hearings proceed speedily and effectively as most polluters, realizing that the law cannot be evaded, offer to comply with the demands of the Committee. The Committee, on the other hand, tries to be reasonable in setting time limits for the preparation of plans, the purchase of needed equipment and the completion of structures. As to the financially weak, it tries to "temper the wind to the shorn lamb" as far as that is possible.

The map entitled "Major Drainage Areas in Wisconsin Used in Stream Pollution Control Activities" (Fig 1) provides a view of the organization of the state for the purpose of pollution control and gives a broad picture of the present status of this control. You will note that a goodly portion of the state comes under "Assigned Surveys Completed." This portion constitutes 54 per cent of the state on an area basis. In the sections so marked the conventional surveys have been made, hearings have been held, orders issued and the carrying out of the orders for satisfactory pollution abatement is in various stages of compliance.

Tables 1 and 2 give further and more detailed information.

TABLE 1. STATUS OF SEWAGE TREATMENT IN WISCONSIN DECEMBER 31, 1952

Degree of Treatment—Population Basis

Degree of Treatment	Connected Population	Per Cent of Total
Complete	1,273,670	58.3
Chemical	71,205	3.3
Primary	668,230	30.6
Untreated	169,741	7.8
Total	2,182,846	100.0

Ninety-two and two-tenths per cent of sewered population is connected to treatment plants.

Degree of Treatment by Communities

Degree of Treatment	Number of Communities	Per Cent of Total
Complete	188	50.9
Chemical	9	2.4
Primary	122	33.1
Untreated	50	13.6
Total	369	100.0

Summary of Progress by Communities Now Discharging Raw Sewage

Status	Number of Municipalities	Population	Per Cent of State Sewered Population
Under Construction	15	41,384	1.9
Plans Approved	13	55,738	2.6
Plans Being Prepared	8	52,265	2.4
No Progress Reported	14	20,352	0.9
Total	50	169,741	7.8

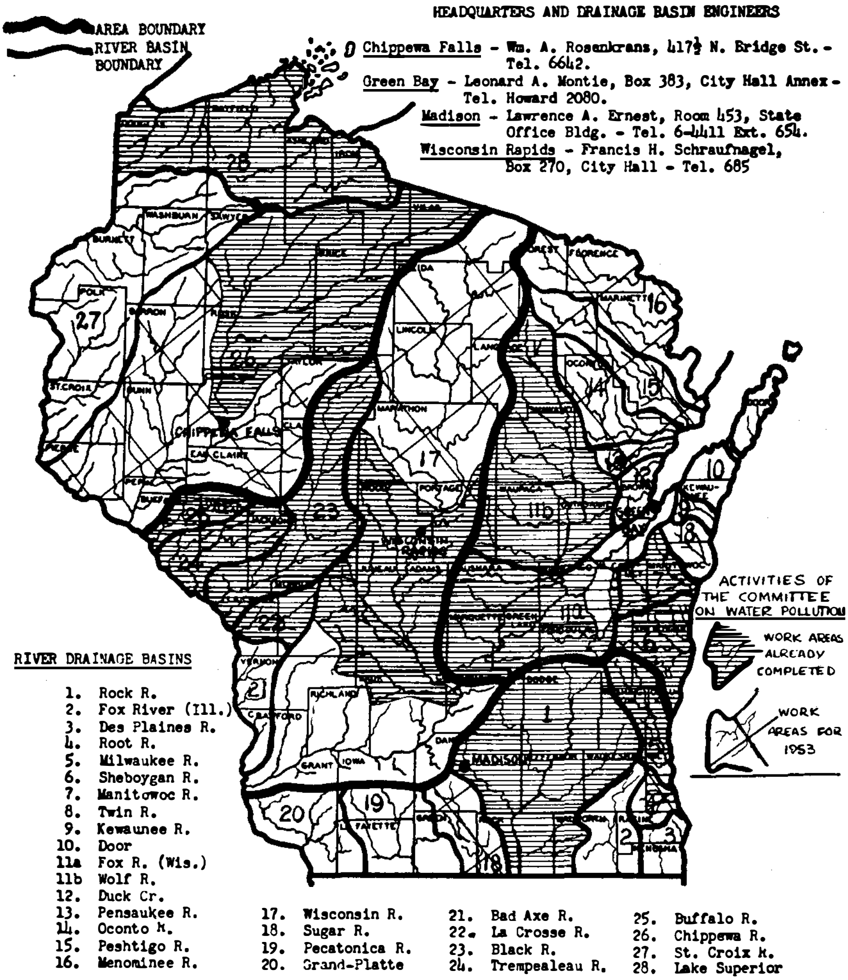
During 1952, six communities which previously discharged raw sewage to streams completed treatment plants. These communities are Chippewa Falls, Hurley, Marion, Oconto Falls, Peshtigo, and Whiting.

In addition, five communities previously without sewers completed construction of sewers and treatment plants during 1952. These are Butler, Iola, Taylor, Thiensville, and Walworth.

During the same period, Augusta, Brillion, and Mukwonago built complete treatment plants to replace primary plants.

MAJOR DRAINAGE AREAS IN WISCONSIN
Used in Stream Pollution Control Activities

15.



Some of the pulp and paper mills are making very substantial investments in pollution abatement structures and equipment:

1. Rhinelander Paper Company (sulphite) for yeast plant and evaporation equipment $1,000,000
2. Bergstrom Paper Mill for solids recovery plant 250,000
3. Consolidated Water Power and Paper Company for evaporation and burning equipment 1,750,000

TABLE 2. STATUS OF POLLUTION CONTROL ORDERS DECEMBER 31, 1952

	Total	Rev.	C.C.	P.C.	U.C.	P.A.	E.R.	D.O.
Prior to 1948								
Municipalities	5	1	3		1			
Milk Plants	5		4		1			
Canneries	4	1	3					
Pulp and Paper								
Other Industries	1	1						
Total	15	3	10		2			
1948								
Municipalities	11	1	5		3	2		
Milk Plants	4		4					
Canneries	2		1		1			
Pulp and Paper	3	1	2					
Other Industries	6	1	3		2			
Total	26	3	15		6	2		
1949								
Municipalities	18	3	8		4	1	2	
Milk Plants	3							3
Canneries	1		1					
Pulp and Paper	14	6	5	3				
Other Industries	4		3	1				
Total	40	9	17	4	4	1	2	3
1950								
Municipalities	21	2	6	1	1	6	5	
Milk Plants	9		2				7	
Canneries	6		4				2	
Pulp and Paper	10	4	1	4			1	
Other Industries	4		2				1	1
Total	50	6	15	5	1	6	16	1
1951								
Municipalities	25	1	2		7		12	
Milk Plants	48		6	2	7	3	13	2
Canneries	17		11			2	4	
Pulp and Paper	16	6	5		5			
Other Industries	15	1	4	2	2	1	5	
Total	121	8	28	4	21	6	34	2
1952								
Municipalities	90	1		1	4	3	13	
Milk Plants	87		2			1	19	1
Canneries	24		1		1	2	2	
Pulp and Paper	5			1				
Other Industries	32	1	1			1	2	
Total	238	2	4	2	5	6	36	1

Rev.—Revised
C.C.—Complete Compliance
P.C.—Partial Compliance
U.C.—Under Construction
P.A.—Plans Approved
E.R.—Engineer Retained
D.O.—Discontinued Operation

4. Hoberg Paper Mills, Inc., for yeast plant 2,500,000
5. Northern Paper Mills for evaporation and burning equipment 2,500,000

Those listed under one, two, three and five have the work completed or nearly so.

ENFORCEMENT

Something ought to be said here about enforcement. The enforcement agent for the Committee is the attorney general, who has as-

TABLE 3. ARRESTS IN REGARD TO STREAM POLLUTION

			Fine
May	1, 1946	United Mining and Milling Company	$100.00
December	11, 1946	Robert Braunschweig	10.00
August	22, 1949	Rockfield Canning Company	35.00
August	23, 1949	Rockfield Canning Company	35.00
August	24, 1949	Rockfield Canning Company	35.00
August	25, 1949	Rockfield Canning Company	35.00
April	14, 1950	Ottis D. Cozad	225.00
			$475.00

signed to it one of his assistants. Up to date it has been necessary to turn 19 cases of non-compliance with orders over to the attorney general for enforcement procedures.

Under the conservation laws previously mentioned, the Conservation Commission has the choice of bringing either criminal action or starting civil suit for the recovery of damages for fish killed as the result of the violation of anti-pollution provisions. The value of the various species of fish is set by statute. At times a compromise as to the amount of damages is arrived at as in the case of a cannery against which a damage claim for $4,900 was pending. On the satisfactory assurance that proper waste disposal facilities would be installed the claim was reduced to $2,500.

Table 3 shows arrests made and fines paid, and Table 4 damages collected under the anti-pollution provisions of the conservation laws.

Of interest in connection with this subject of damages is the decision of the municipal court of Outagamie County which awarded muskrat farmers damaged by pollution the sum of $3,000. (Bartenstein et al. vs. Fox River Valley Canning Company and Village of Hortonville 1952). The judge decreed as follows:

> "1. That the defendants, Fox River Valley Canning Company, a corporation, and Village of Hortonville, a municipal corporation, jointly pay to the plaintiffs the sum of Three Thousand Dollars ($3,000.00) within ten (10) days from September 19th, 1952 in full settlement of damages sustained by the plaintiffs, without costs.

TABLE 4. DAMAGES COLLECTED IN REGARD TO STREAM POLLUTION

August	30, 1944	Kraft Cheese Company	$ 500.00
September	23, 1944	Columbus Foods Corporation	250.00
October	18, 1944	Rockfield Cannery Company	2,000.00
August	25, 1945	Laabs Dairy Company	250.00
September	11, 1945	Central Wisconsin Canneries	2,500.00
February	24, 1947	Goodman Lumber Company	250.44
June	3, 1947	Herbert A. Nieman	1,000.00
February	20, 1948	Central Wisconsin Canneries	210.00
February	14, 1949	Alder Cheese Company	386.50
August	11, 1949	Chicago, St. Minneapolis and Ohio Railway Company	63.00
August	21, 1950	Hustisford Canning Company	75.00
September	7, 1950	Oconomowoc Canning Company, Stratford	800.00
			$8,284.94

"2. It is further ordered, adjudged and decreed, that the defendant, Fox River Valley Canning Company, and their agents and servants, are hereby perpetually enjoined and restrained from throwing or depositing or permitting the emptying into Black Otter Creek, a stream within the jurisdiction of the State of Wisconsin, of any acids, chemicals, sewage, industrial or other waste and refuse or any other substance deleterious to fish, animal, wild game, or plant life, and deleterious and injurious to plaintiffs' fur farm and to comply with future laws and lawful orders.

"3. It is further ordered, adjudged and decreed that the Village of Hortonville forthwith comply with all present orders, regulations and directions of the State Board of Health and of the Committee on Water Pollution of the State of Wisconsin in its operation of its sewage disposal plant and system before allowing any effluent from said sewage disposal plant and system to flow into Black Otter Creek, and to comply with all future lawful orders, regulations and directions of the State Board of Health and of the Committee on Water Pollution of the State of Wisconsin, insofar as the said present and lawful future orders, regulations and directions pertain to the effluent discharging into Black Otter Creek; and that the Village of Hortonville, its agents and servants, are hereby perpetually enjoined and restrained from throwing or depositing or permitting the emptying into Black Otter Creek of any acids, chemicals, sewage, industrial or other waste and refuse or any other substance deleterious to fish, animal, wild game or plant life insofar as the same shall be violative of the laws of the State of Wisconsin and of said present and future lawful orders, regulations and directions."

Decisions of this kind give valuable support to the Committee in its demands for pollution cleanup.

Two decisions of the Wisconsin Supreme Court heavily underscored the authority of the Committee and greatly strengthened its position in its dealings with reluctant or evasive violators.

On October 19, 1949 the Committee on Water Pollution issued the following order to the Madison Metropolitan Sewerage Commission:

"Complaints having been made from time to time of odor nuisances in the Madison Lakes and particularly in Lakes Monona, Waubesa and Kegonsa and it appearing from various investigations, surveys, studies and public hearing relating thereto and particularly the public hearing held before this Committee on August 30, 31 and September 1 and 12, 1948, that such nuisance and pollution is caused primarily from the decay of plant growth in said waters, which plant growth is excessively stimulated by the effluent from your sewage treatment plants, said nuisance and pollution conditions having resulted among other things in the enactment of Chapter 435, Laws of Wisconsin for 1949; it further appearing that both your present Burke and Nine Springs plants are within ten miles of each of such lakes, which are each more than two square miles and less than six square miles in area:

"NOW THEREFORE, Pursuant to said Chapter 435, Laws of 1949 and Chapter 144 of the Wisconsin Statutes, IT IS ORDERED:

"1. That on or before March 1, 1950 you shall submit to this Committee preliminary plans for eliminating the discharge of untreated sewage or treated sewage effluent from any and all of your present plants or from any primary or secondary plant into any of the above-named lakes.

"2. That on or before June 1, 1950 you shall submit to this Committee Final Plans for eliminating any such discharge into any such lakes.

"3. That in accordance with said Final Plans your present method of disposing of sewage effluent be modified and improved and construction completed by not later than June 1, 1951 so as to eliminate the discharge of said untreated sewage or effluent from a primary or secondary treatment plant either directly or indirectly into any lake of more than two square miles or less than six square miles in any area located within ten miles of your plants (which includes Lakes Monona, Waubesa and Kegonsa).

"4. In lieu of the actual construction in compliance with paragraph 3 of this order you may file with this Committee on or before June 1, 1950 such plans for advanced treatment of your effluent as in the judgment of this Committee will accomplish substantially the same results in eliminating the nuisance conditions as would be accomplished by diversion of the effluent from the above-named lakes (without at the same time creating other objectionable or damaging results).

"5. That your sewage and waste treatment plant be operated and maintained at all times so as not to create a nuisance or water pollution."

The Madison Metropolitan Sewerage Commission asked for a review of the order by the Committee which held the required hearing and affirmed the order. So did the Circuit Court, which was asked to review the order. On appeal, the Supreme Court affirmed the judgment of the first court, finding as the latter did with reference to the facts as well as to the constitutional objections raised by the appellant. As to these objections, the Court stated:

> "It is our opinion that there are no constitutional objections to the statute in question and, further, that if there were, neither the petitioner nor intervenors may assert them. The judgment affirming the order of the Committee on Water Pollution is affirmed." (Madison Metropolitan Sewerage District vs. Committee on Water Pollution et al. 160 Wisconsin 229, 50 N.W. [2] 468).

In another case action for declaratory judgment was started by the City of Superior against the Committee on Water Pollution. The defendant interposed a demurrer on the grounds that the complaint failed to state facts sufficient to constitute cause for action. The demurrer was sustained, but the plaintiff was granted the privilege of amending its complaint within 20 days. Failing to do so, the court dismissed the case. The Wisconsin Supreme Court affirmed the judgment of the trial court, calling attention to the "Juneau Case" as authority for the principle that where a specified method of review is prescribed by statute, the method so prescribed is exclusive."

This paper may very well come to a close with the following citation from the "Juneau Case":

> " . . . In no field is the power of the state broader and more general than in the protection and promotion of the public health, —a matter which concerns not only the state in its corporate capacity but every individual within it. It is principally because municipalities are indifferent to the increasing demands made upon them by our advancing civilization in the field of education, transportation and health that local bodies have been so largely divested of powers and been made subject to legislative regulation and supervision by state authority. The case which we are considering is a glaring instance of the disregard of public welfare in the interest of objecting taxpayers." (State ex rel. Martin vs. Juneau, 238 Wis. 564 at 569-70—300 N. W. 187).

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2. Wisconsin Laws of 1949, Chap. 603
3. 160 Wisconsin Reports
4. 238 Wisconsin Reports
5. 50 N. W. Reporter
6. 300 N. W. Reporter

DISCUSSION

DR. BENNETT: Mr. Cramer has given us a blueprint for pollution control in Wisconsin. Are there any questions or discussion?

MR. JOHN DEQUINE (Florida): I just want to ask a minor question. I was interested in your mention of the assessment of a $4,900 fine against a company which was later reduced to $2,500. What was your basic formula for that evaluation of the fish killed, which I assume—

MR. CRAMER: We have a statutory value on certain fish, all the way from two dollars, each fish. We counted the fish, and there were just so many. I think they were two dollars per head in that case.

That is a statutory provision. Although the game has been assigned a certain value by your statutes, trout are higher than are other types of fish.

MR. CHESTER S. WILSON (Minnesota): Mr. Chairman, being a member of the Minnesota Water Pollution Control Commission, and in very close touch with the Wisconsin Water Pollution Control Committee, I have listened with a great deal of interest to my good neighbor's paper on this subject, because we worked very closely with them in handling cases on our boundary, to the extent that I do not think we are going to need any help from federal authorities in solving the problems on the boundary waters between Minnesota and Wisconsin. But I just want to ask Mr. Cramer for information up to date as to whether your Committee has reached any municipal cases, where you have had to apply any penalties similar to those you have enforced against industry.

MR. CRAMER: No, we got pretty close to it in the case of certain cities. You probably know which ones I mean.

MR. WILSON: I just wondered whether you had gotten to the picking point yet.

MR. CRAMER: No, they backed down eventually. We had to go to some length with Superior.

MR. WILSON: What would you do, under your law, if you got an absolutely recalcitrant municipality, which disobeyed an order, if the ultimate deadline had been reached?

MR. CRAMER: Well, we would probably enforce the statutes, $250-a-day fine for every day of noncompliance.

MR. WILSON: Well, now, that raises an interesting question. I wonder if it is good policy to take money away from a municipality when they need that money badly to help pay the cost of a sewage-treatment plant.

MR. CRAMER: Well, there is one way out. They can comply with the orders. They have their choice. If they would rather pay the fine than spend the money for the installation of sewage-disposal facilities—

MR. WILSON: How long would you keep up that collection? You cannot go on squeezing money indefinitely out of a community which is already so hard up it cannot build a sewage-treatment plant.

MR. CRAMER: Well, that is more of an academic question.

MR. WILSON: Well, I hope it is academic; but I just wonder, if in Wisconsin or anywhere else, they have ever considered this expedient; that is, to set up some kind of a sinking-fund system whereby, in case you do get to the point where you have to enforce these money penalties against a municipality, that money would be set aside in a fund to be the nest egg for starting a fund for construction of a sewage treatment plant.

MR. CRAMER: Well, from all our past experience, we are quite certain we will never have to go to that length. We did not have to go to any length with industry either; in fact, we have obtained our objective by the negotiations and education and friendly conferences with all those concerned. In many cases, we do not hold any formal hearings; we invite the city council and the mayor, the industry, to a friendly conference, and, in most instances, we arrive at some kind of agreement.

I say we are reasonable in setting time limits, and we are trying to help those communities which are short of funds, by advising them how to get around that problem.

MR. WILSON: Well, we followed the same policy in Minnesota. We are familiar with your procedure, and working pretty much along the same lines; but, after hearing you read the number of orders you had issued, I just wondered whether you had gotten to the point where you really had to crack down on a municipality.

MR. CRAMER: We had 19 cases where we had to turn the matter over to the attorney general.

MR. WILSON: But they did not reach the point of actually collecting the fines?

MR. CRAMER: I do not believe, in any case, where a municipality was concerned; I do not remember any of those cases.

STATUS OF THE COOT IN THE MISSISSIPPI FLYWAY

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and
ARTHUR S. HAWKINS
U. S. Fish and Wildlife Service, Minneapolis, Minnesota

It is our hope that the outgrowth of this report will be a better understanding of the role the Coot (*Fulica americana*) is playing in the Mississippi flyway waterfowl picture and a realization that we need to know more about this species if we are to apply management principles wisely.

Knowledge of the habits and population trends of most species of migratory game birds has increased steadily in recent years. Through improved programs of censusing, banding, estimating kill, evaluating habitat, and studying the ecology of individual species, conservation agencies have uncovered facts which are basic to sound management of this wildlife resource. In our opinion, however, at least one species, the American coot, has been relegated a position of secondary importance in most investigations.

We propose (1) to discuss the coot *versus* duck controversy and the extent of indifference toward the coot; (2) to show the importance of the coot in waterfowl hunters' bags and in the total waterfowl population of this region; (3) to report trends in the breeding population and nest statistics from Manitoba; and (4) to point out many shortcomings in our knowledge of the coot.

Reference to coots of the Mississippi flyway is not meant to imply that the Mississippi flyway population is a distinct unit. Banding results were not available to show migration patterns of coot populations.

ACKNOWLEDGEMENTS

Manitoba breeding population data reported here were gathered with the cooperation and financial support of the U. S. Fish and Wildlife Service, the Wildlife Management Institute, the Wisconsin Alumni Research Foundation, the University of Wisconsin, and the Manitoba Game Branch. We wish to thank J. J. Hickey, R. A. McCabe, and J. P. Linduska for critically reading portions of the manuscript.

THE COOT—OBJECT OF CONTROVERSY AND INDIFFERENCE

The coot (also known as mudhen, *poule d'eau,* whitebill, and commonly referred to as the "lowly" coot) gained prominence in the role of a villain allegedly responsible in part for the duck decline of the thirties.

Brooks (1941) was of the opinion that coots were responsible for great declines in the number of certain species of ducks through conflicts both on the breeding grounds and on wintering areas. He advocated that all protection be taken from the coot, and that "All real bird lovers should bend their energies toward some action that will mitigate or abolish the menace of the mudhen."

Munro (1939a), working in the same region mentioned by Brooks, concluded on the basis of numerous field observations on brooding lakes in British Columbia that there was no evidence to indicate that the coot was adversely affecting duck broods to any appreciable extent. A brood study in southwestern Manitoba reported by Evans, Hawkins, and Marshall (1952) gave similar results in that no evidence was found to show a decrease in the use of potholes by ducks because of interference from coots. Bennett (1938), working in Iowa, stated that despite combats between blue-winged teal (*Anas discors*) and coots, no observations were made of teal being evicted from a desirable nesting area by coots. Low (1940), also in Iowa, recorded successful redhead nests within one yard of successful coots nests.

Our observations extending over seven waterfowl breeding seasons in Manitoba pothole habitat did not reveal conflicts between ducks and coots that we could interpret as being detrimental to the ducks.

Food habits of the coot have been studied in a broad scope and found to be normally inoffensive in an economic sense, although some depredation on agricultural crops in California was reported (Jones, 1940). Studies to determine coot-duck food relationships on specific areas have been reported by Munro (1939b) on Swan Lake, British Columbia, and Stollberg (1949) on Horicon Marsh, Wisconsin. Both investigators found no important competition for food between ducks and coots during fall months.

The feeling that the coot might be competing with the more favored ducks has been widespread. Fish and Wildlife Service "Status of Migratory Bird Reports" portray the trend in feeling over a period of years. The 1940-41 status report expressed the opinion that on refuges in the northern United States the coot was too abundant in view of its aggressive disposition toward other birds. A quotation from the 1943-44 status report follows: "The coot continues to increase and its management may become a serious problem. Sportsmen would help if they would add some of these birds to their bags. Properly prepared they are a good table bird. Directions for cooking coots may be obtained from the Fish and Wildlife Service."

Indifference toward the coot is prevalent even today. Evidence that the species is not deemed important is found in the almost complete lack of published data on breeding population trends. When populations are surveyed, as, for example, in the winter inventory of the Fish and Wildlife Service, we feel it is likely that observers consider coots of secondary importance and estimates of their numbers are made roughly. This is most likely the situation when ducks and coots occur together in large concentrations and attention is focused on the ducks.

Waterfowl hunters in general do not prize the coot as a game bird. To the majority, the coot is not up to standard in sporting and/or eating qualities. It is open to question whether the supposed lack of culinary appeal is in fact real and a valid reason for shunning the coot. Coot shooting, to the majority of waterfowl hunters, does not offer thrills comparable to ducks hanging over the decoys or whistling overhead in the early dawn. There are, however, a substantial number of hunters who by choice go coot hunting, not duck hunting.

REGULATIONS AND KILL STATISTICS

Regulations. — The coot, being included in the provisions of the Migratory Bird Treaty Act, has been given the protection afforded other migratory game birds. Regulations have, of course, fluctuated through the years. The trend has been from an open season of over three months and a daily bag limit of 25 birds in 1918 to a season of 30 days and a bag limit of 15 coots per day and 15 in possession in 1935 (a result of the drouth which struck waterfowl production with full force in the early thirties). After 1935, regulations became more liberal until 1946 when restrictions were tightened. In 1948 the bag limit was reduced from 25 to 15 birds per day and in possession. Since 1949, seasons have become more liberal, but the bag limit, cut to 10 birds per day and in possession in 1949, has remained the same through the past four hunting seasons.

Kill statistics.—The Fish and Wildlife Service has published kill statistics for the 1949-1951 hunting seasons. Crissey (1951) and Williams (1952) compiled the data and described the methods employed. Statistics were compiled by flyways and were based on the average daily kill (determined by bag checks in the field), average number of times hunted (determined by postseason contacts of hunters), and average duck stamp sales for each state in the flyway (corrected to compensate for philatelic purchases and for hunters who purchase stamps and then do not hunt waterfowl). Williams pointed out limitations of the method and stated that experience has shown that hunters were not contacted in a representative fashion, but rather that the more successful hunters supplied much of the kill data with the result that estimates of waterfowl kill are biased upward by an unknown amount. However, trends are probably detectable from these data. Williams reported progress in organizing a system of representative sampling of all duck stamp purchasers through cooperation of the Post Office Department.

In our estimation, there is a possibility that species composition of the kill is biased also. In considering the coot, for example, a disproportionate number of opening-day or opening-weekend hunter checks to determine average daily kill would result in an overestimation of the seasonal coot kill, we believe, since more coots are killed on the opening day, and in general during the first portion of the season, than at later dates.

Despite their limitations, the kill statistics give an indication of the relative importance of the coot in the total waterfowl kill of the four flyways (Table 1.) In all three years, 1949-1951, the estimated coot kill in the Mississippi Flyway was more than three times as great as the combined kill in the other three flyways. On a species basis, only the mallard (*Anas p. platyrhynchos*) ranked above the coot in estimated number of waterfowl bagged in the Mississippi Flyway. The coot assumed importance in hunters' bags in the Atlantic Flyway, also. Here, based on Fish and Wildlife Service kill statistics compiled for more than 20 species of waterfowl, coots ranked second, fifth, and fourth in the seasonal waterfowl kill for the three-year period. On the other hand, the kill of coots in the Central and Pacific Flyways was light in comparison to the duck kill.

SHOOTING PRACTICES

Concentrated kill on traditional coot lakes.— Areas where the bag of coots far exceeds the bag of all other waterfowl species combined are found in the Mississippi Flyway. Annually these areas attract large concentrations of coots during the fall migration. Hunters recog-

TABLE 1. COOT KILL STATISTICS FOR THE UNITED STATES.
[After Crissey (1951) and Williams (1952).]

		Hunting season		
		1949-50	*1950-51*	*1951-52*
Atlantic Flyway	Estimated coot kill	304,008	190,852	230,207
	Per cent of total waterfowl kill[1]	12.1	6.9	9.0
	Rank	2	5	4
Mississippi Flyway	Estimated coot kill	1,391,509	970,780	1,775,802
	Per cent of total waterfowl kill	13.2	12.9	15.4
	Rank	2	2	2
Central Flyway	Estimated coot kill	23,721	6,793	36,115
	Per cent of total waterfowl kill	<1.0	<1.0	<1.0
	Rank[2]	....	....	....
Pacific Flyway	Estimated coot kill	37,076	90,279	119,017
	Per cent of total waterfowl kill	<1.0	1.5	1.4
	Rank	....	8	8

[1]Over 20 species of waterfowl included in kill.
[2]Rank lower than 10 not reported here.

nize this fact and with equal regularity flock to these lakes for coot shooting, particularly during the early part of the season. Lakes which are known as traditional coot lakes include Lake Puckaway in Wisconsin, Grass Lake in Illinois, Wolf Lake in Indiana, and the Howze's Beach portion of Lake Pontchartrain in Louisiana.

Bellrose (1944) reported statistics on the coot kill at Grass Lake in the glacial lakes region of Illinois. On the opening day of the 1942 waterfowl season, he calculated 1,920 hunters on the 1,800-acre lake, a density slightly greater than one hunter per acre. A census of the coot population on the day preceding opening day revealed an estimated 25,000 coots on the lake. Based on bag checks, average hunter success was calculated to be 12.4 coots and 0.11 ducks on the first day of the season. On this basis, the first-day kill on Grass Lake was about 23,800 coots and 211 ducks. Estimates of the coots remaining on the lake following the shoot were made. These before and after censuses plus the calculated kill led Bellrose to conclude that about 90 per cent of the coots on Grass Lake were killed on opening day.

In 1943 Bellrose made a similar check of Grass Lake, calculated that 18,225 coots and 108 ducks were killed the first day of the season, and concluded on the basis of censuses that 95 per cent of the coots present the day prior to the season opening were killed before noon of opening day. He points out that hunting pressure declines markedly after the first-day shoot in this region of Illinois.

Jahn (1952) reported statistics which illustrate the high coot kill during the first portion of the open season in Wisconsin. Sixty-four per cent of the seasonal coot kill was made the opening one and one-half days of the 1951 season at four permanent all-season checking stations located on Horicon Marsh, Lake Puckaway, and two points on the Mississippi River. This is in contrast to 36 per cent of the total seasonal duck kill made on the same dates.

Coot reaction to hunting pressure.—On traditional coot shooting lakes in the Mississippi Flyway, hunting pressure is extreme during the first few days of the season—the period when a high percentage of the total seasonal coot kill is made (Bellrose, 1944; Jahn, 1952).

We observed the behavior of coots under fire from a heavy concentration of hunters on Lake Puckaway, Wisconsin, in 1949. When the season opened at noon, a steady, unbroken rumble of shots rolled over the lake. Coots took to the air and milled around the lake, seldom, if ever, flying high enough to be out of shotgun range. The density of hunters precluded the coots' seeking refuge in the emergent aquatic vegetation. It was apparent that the heavy concentration of hunters resulted in a high kill of coots because the birds were kept moving at all times and would not leave the lake. There is probably a positive correlation between the number of hunters and hunter success, perhaps to the point where the number of hunters is sufficient to keep the coots milling around.

Unretrieved kill.—In addition to reported kill, large numbers of coots are shot and deliberately not retrieved. Baumgartner (1942) stated that a majority of hunters on Lake Carl Blackwell, Oklahoma, did not bring in coots they had shot. At Forney Lake, Iowa, a controlled waterfowl hunting area, Teer (1952) found that warning hunters against shooting birds and not retrieving them stopped the waste of unretrieved coots reported in previous years. Reports in Fish and Wildlife Service files indicate that U. S. Game Management Agents frequently find hunting areas where substantial numbers of coots are shot and not retrieved.

It is probable that many coots are shot by duck hunters who are having poor success and think of coots only as targets to provide action when ducks are not flying.

There is evidence also that coots are shot when mistaken for ducks. Hawkins found evidence of coot kill due to mistaken identity at the Spring Lake Public Shooting Ground, Savanna, Illinois, on October 26, 1946. In the early morning of a dull, overcast day, hunters had difficulty in differentiating the various species of waterfowl present. A bag check showed that 125 hunters killed 76 ducks, 308 coots, three grebes, and five cormorants. Large numbers of dead coots were seen floating on the water later in the day, undoubtedly birds that were shot in the early morning, for shooting quickly subsided when light conditions became better.

Increased hunting pressure on coots.—Has hunting pressure on coots increased? It seems safe to say that with the increase in number of waterfowl hunters as shown by duck stamp sales, the hunting pressure on coots has increased also. Kill statistics show an upward trend in number of coots bagged each year. Lower duck limits and the scarcity of ducks in many areas bring coots to the attention of an ever increasing number of hunters who are looking for action on a dull duck day or for more targets when a limit of four or five ducks has been bagged.

Although we have no definite figures to show a trend, it seems that there is less prejudice against the table qualities of this bird today than in the past. Conservation agencies have made attempts to point out that the coot is a game bird of good edibility.

POPULATION TRENDS

Waterfowl technicians are satisfied that techniques now in use measure trends in duck populations over vast areas. In our opinion, coot population trends for units the size of flyways or larger have not been determined satisfactorily.

Winter inventories.—The only published information (Crissey, 1951; Williams, 1952) on trends in flyways or for the continent is based on Fish and Wildlife Service winter inventories. These data, however, have several inherent weaknesses. Perhaps the most important one stems from the fact that coots are often regarded with indifference. There is growing evidence that the coot has become a major target for hunters, but past indifference on the part of many wildlife administrators and technicians has not been conducive to gathering data needed in managing this species. For example, we believe that in censusing regions where coots and ducks occur together in large concentrations, observers commonly devote most of their attention to the ducks and only roughly estimate the numbers of coots.

Aerial counts of coots probably are less reliable than those of ducks because from the air a dark bird against a dark background is more difficult to see than a light bird (most ducks) against a dark background. This would not necessarily affect trend figures but would tend to play down the relative numbers of coots as compared to ducks. Even so, winter inventory figures show the coot to rank numerically with the most numerous waterfowl species of the continent (Table 2). During the period of three winter inventories—1949-50, 1950-51, and 1951-52—the coot, on a species basis, has ranked no lower than sixth

TABLE 2. COOT RATING IN CONTINENTAL WINTER INVENTORY
[After Crissey (1951) and Williams (1952).]

		Winter inventory		
		1949-50	*1950-51*	*1951-52*
Atlantic Flyway	Per cent of total waterfowl[1]	17.2	12.9	11.0
	Rank	1	2	2
Mississippi Flyway	Per cent of total waterfowl	5.9	4.0	8.4
	Rank	5	5	3
Central Flyway	Per cent of total waterfowl	8.6	6.9	13.8
	Rank	5	3	5
Pacific Flyway	Per cent of total waterfowl	5.5	9.5	7.4
	Rank	4	3	6

[1]Over 20 species of waterfowl included in inventory.

in the total number of waterfowl seen in any one of the four flyways.

In addition to the lack of interest and technical difficulties involved in counting coots, there is the unsolved problem of linking wintering concentrations with their flyways and breeding grounds. Do the same relative numbers of coots from the Central Basin of Manitoba winter along the Atlantic, Gulf, and in Mexico each year, or do these wintering populations shift depending on conditions along the flyways and at terminal points? Winter inventory figures have established that numerically the coot is one of our most important waterfowl species. However, for reasons given, the inventory has not provided as high a degree of accuracy for establishing annual trends or estimating total populations as is desirable for management purposes.

Breeding ground surveys.—Do breeding ground surveys provide more reliable figures than the winter inventory for establishing trends? In our opinion, not up to the present time. It is probable that breeding ground surveys could measure overall trends in the coot population, but trend statistics are unreported for large segments of the breeding range today.

Problems of counting coots by aerial or ground census also arise on the breeding grounds. The nature of the habitat of the coot plus its reactions when disturbed and its color are among factors which probably pose greater obstacles in censusing than are encountered with most ducks. Experience in Manitoba in 1952, however, led us to believe that important changes in coot numbers on the breeding grounds can be detected. Various types of ground, canoe, and aerial transects all indicated a decrease of more than 40 per cent in the coot population of Manitoba. Both aerial and ground censuses hold promise if the effort to record coots is on a par with that for ducks and climatic and phenological conditions are considered.

In Manitoba the bulk of the coot population normally arrives by May 1 and starts nesting about May 10. This 10-day interval appears to be the optimum time for censusing and is also a desirable period for counting breeding pairs of early-nesting ducks such as mallards, pintails (*Anas acuta tzitzihoa*), and canvasbacks (*Aythya valisineria*). Coots appear somewhat more sensitive to wind than ducks, and velocities above 12 miles an hour probably reduce the accuracy of the count sharply. Time of day is important because most coots go to roost shortly after sunset. Ducks, in contrast, are increasingly active at that time.

1952 decline in Manitoba.—Manitoba, with its famous residual marshes of glacial Lake Agassiz, the eastern half of the Saskatchewan River delta, and about seven per cent of the Prairie Pothole Region (the continent's best waterfowl production unit), is believed to be a major contributor of coots to the Mississippi Flyway. The 1952 decline in Manitoba's coot population was so spectacular that we immediately took steps to determine, if possible, how widespread the reduction was. Did it indicate a possible "crash" decline in coots due to some factor superimposed on shooting mortality, was increased shooting pressure alone responsible, or did many coots desert Manitoba because of the threat of drouth? Our efforts to obtain information from other areas included a questionnaire distributed to Fish and Wildlife Service field men in the 11 north central states within the Service's Region III, and conferences with co-workers in Saskatchewan and in some of the northern tier of states.

On the basis of information from these sources, we concluded that coot breeding population data gathered in the major portion of the Prairie Pothole Region were inadequate to determine an over-all trend. Data were not available from other regions to show whether or not a shift in the population had occurred to avoid semi-drouth conditions in Manitoba. On the basis of observations on coot nesting habitat preferences in pothole country during both dry and wet years, we suspect that coots are more sensitive than ducks to drouth and are capable of moving considerable distances to avoid conditions which threaten their nesting habitat. Such a trait would be an important attribute for species survival in regions subjected to periodic drouth. It is, perhaps, one reason why coots seemed to fare better than ducks during the drouth years of the thirties and to bounce back more rapidly when water conditions began to improve in some regions while drouth still persisted in others. We wonder, however, what would happen if drouth spread over the entire Prairie Pothole Region, since coots require the marsh type for nesting, a type which is rare over most of the far North.

Newdale-Erickson district nesting study.—One phase of a waterfowl productivity study in the Newdale-Erickson district of southwestern Manitoba included observations on coot breeding population trends and nesting. Twelve transects were established in this district which includes over 4,000 square miles of excellent pothole habitat for waterfowl. On these transects, 120 potholes were chosen at random to be studied intensively.

There was a downward trend in population and nests in this district from 1949 through 1952. Breeding coots and nests on study potholes decreased 53 per cent and 58 per cent, respectively, while coots on the transects as a whole declined 62 per cent in this four-year period. The decrease was greatest in 1952 when the population on transects dropped 44 per cent below the 1951 level. Numerically, the transect population, an index to the actual number of coots on transects, declined from 623 in 1949 to 238 in 1952 or from 12.4 to 4.7 coots per square mile.

Nest statistics compiled for the four years show the coot to be highly successful in this district. Based on 380 nests over the four-year period, coots were 97 per cent successful in hatching their clutches. The mean clutch size based on 169 nests with complete clutches was 9.88 (standard error 0.12) eggs. Egg hatching success was 99 per cent of 1,394 eggs in successful nests with complete clutch counts.

Brood census techniques used on study potholes were designed primarily for ducks and were not well adapted to counting coot broods. We were guilty of assigning coots to a back seat while concentrating on ducks—a very common occurrence! In censusing coot broods, some behavior traits that should be considered are (1) the young are often divided between the two parent birds; (2) once disturbed, both young and adults seek cover in the emergent vegetation and frequently remain hidden despite various efforts to dislodge them; and (3) young coots generally go to roost on platforms earlier in the evening than young ducks and hence are less countable at a time well suited for censusing duck broods. Since techniques for counting coot broods differ from those we used for ducks, the coot brood data obtained incidentally are incomplete and are not reported here.

SUMMARY

The coot, in the opinion of some writers, is a villain competing with ducks on breeding and wintering areas. However, several detailed studies have found no evidence that coots importantly compete with ducks. Hunters, in general, do not prize the coot as a game bird. Many professional wildlife workers regard the coot with indifference.

Kill statistics, as compiled by the U. S. Fish and Wildlife Service in the past, have acknowledged limitations but serve to indicate that

the coot has come to rank as an important component of the total waterfowl kill. For three hunting seasons, 1949-1951, only the mallard ranked above the coot in number of waterfowl bagged in the Mississippi Flyway. More than three times as many coots were shot in the Mississippi Flyway as in the other flyways combined during these seasons.

Traditional coot lakes are sites of high concentrations of hunters and heavy coot kills during the first days of the open season. At Grass Lake, Illinois, Bellrose calculated the hunter density to be greater than one hunter per acre on the 1,800-acre lake on the opening day of the 1942 season. He estimated that 90 per cent of 25,000 coots present prior to the season opening were killed the first day of the open season. At Lake Puckaway, Wisconsin, coots subjected to high hunting pressure did not leave the lake but milled around, seldom, if ever, flying above shotgun range. In many hunting areas, coots are shot only as targets and deliberately not retrieved. Hunting pressure on coots has probably increased due to the growing number of waterfowl hunters, low duck bag limits, scarcity of ducks in many areas, and, perhaps, less prejudice against the coot as a table bird. Kill statistics show an upward trend in the coot kill.

Population trends in coots for units the size of flyways or larger are not well known due to census difficulties and widespread indifference toward the species. Winter inventories indicate that coots rank high numerically in the total waterfowl population of the continent. Breeding ground surveys lack good techniques for counting coots and do not permit comparisons of regional data to detect over-all trends in the population. In Manitoba in 1952 various methods of survey indicated a decline of over 40 per cent from the 1951 breeding population level. Whether this decline represented a reduction in the coot population as a whole or a shift in the local population to avoid semi-drouth conditions in Manitoba is not known. Coots on a study area in southwestern Manitoba declined 62 per cent since 1949. On the same area over the four-year period, 1949-1952, 97 per cent of 380 coot nests hatched successfully.

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THE AMERICAN COOT AS A GAME BIRD

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In Canada the breeding range of the American Coot (*Fulica americana americana* Gmelin) overlaps that of the ducks and it is a common nester on all the marshes of the West. Like the ducks it reaches its greatest abundance in the alkaline waters of the pothole country of Manitoba and Saskatchewan. Working in this type of terrain, E. N. Cole, (1949:69) recorded densities of 12 per square mile. In the more acid lakes of the Canadian Shield, the coot, like the prairie ducks, is an uncommon breeder despite the abundance of water.

The coot is not among the earliest waterfowl to arrive in spring. At Delta I have never sighted coots before April 14th and often they do not come until after the first mallards and pintails have begun nesting. The bulk of the coot migration occurs during the first week of May. However, it is not uncommon to hear these nocturnal fliers in passage through the remainder of the month.

Within a short time after arrivel, many of the coots have set up territories, the size of which depends largely upon the type of habitat and competition from other pairs. Along the fringes of the Delta marsh, territories normally include about 30 yards of shoreline, but in the smaller waters of the pothole country I have found as many as six breeding pairs on an acre pond.

The coot pair stays together throughout the nesting season, but the male remains for only a part of the rearing period. In common with other waterfowl, the coots have a flightless period in which they shed all the wing feathers and for more than two weeks are unable to fly. Like the ducks, many of the males of the species band together at this time on the larger marshes. At Delta, small gatherings of unattached coots are first noticed in late June. By mid-July these have grown to 500 or more birds, the majority of which are unable to take wing. The limited number of specimens I have collected from these wary flocks have been males which I presume have abandoned their families. The female is more faithful to the young, and I have frequently found shed primary and secondary feathers about the family platform, evidence that she moults her wing close to her brood. Indeed, many times I have seen flightless adults which I identified as females attending a brood.

The first young coots are seen at Delta early the second week of June. They are incapable of feeding themselves and must be fed by one of the parents. In the European coot, Boyd and Alley (1949:582-593) noted that "in their first few days coot chicks are just as dependent upon their parents for food as are passerine nestlings . . ." The young begin diving during their second week, develop the first feathers during the third, and are capable of flight by the eighth.

For the first five weeks the young coots live almost entirely within the confines of the parents' territorial boundaries. After the fifth week, however, there appears to be a breakdown in territorialism, and broods from neighboring areas mingle and feed together, although returning at night to their respective platform nests. Beyond the seventh week the young are on their own at Delta and I have caught these flightless juveniles traveling overland in early August from the back marsh areas to join bands of young already forming on the larger bays, evidence of the family break-up.

The build-up of local flocks is progressive throughout August. At first it is merely the merger of two or three of the oldest families in each local. These birds no longer hug the shoreline of the old home territory but feed out in the open water of the bays, running for shelter at the first sight of danger. By mid-August at Delta the majority of young have reached the flying stage and are in bands numbering a hundred birds or more.

The movement outward and away from the territory is not confined to the Delta Marsh. I have seen rafts of coots which I estimated from the air to contain 15,000 birds feeding far from shore on Oak Lake as early as August 12th. Again, Crescent Lake in the town of Portage la Prairie, 16 miles south of Delta, usually has hundreds of coots on its surface by the end of August. I am certain that only a small portion of birds present were raised on these areas. After the middle of August we frequently find dead birds of the year beneath telephone and hydro lines crossing flight passes, evidence, I believe, of the invasion of young birds from other areas.

Doubtless the late summer dispersal is a continuous process with the young leaving the smaller water areas shortly after they are able to fly. By early September only a few coots, probably late-hatched young, remain on the sloughs and potholes.

I am not certain of the behavior of the male coot beyond the flightless stage. However, large bands stay throughout the summer on a few favored areas within the marsh, and since adult males are present in autumn gatherings, I suspect they remain to be absorbed in the general build-up of autumn populations.

The fall flights of the coot are not easily followed, for the calls, by which we observe spring migration, are less commonly uttered. Although I have observations on many scores of spring arrivals, I have only a handful of accounts of autumn departures. In either season, a bright moon appears to be one of the prime requisites for heavy coot movement. There are several waves in the fall migration of the coot from southern Manitoba. At Delta the first of these formations attains its peak in late August or early September. In 1951 I made an aerial census of the east half of the marsh on August 27th and estimated 10,500 coots to be present. The dimension of this build-up is illustrated when measured against a spring breeding census of 400 birds for the same area. During this early migration period the coot ranks in abundance with the mallard and blue-winged teal. Like the early bluewings, these aggregations depart before the middle of September.

The second build-up grows through the remainder of September, reaching its climax in early October. Doubtless it is made up of birds working their way southward from the marshes of northwestern Manitoba. When the waterfowl season opened at Delta the third week of September, the coot was a very abundant bird on the marsh. Oldtimers still tell of the myriads of coots that filled the bays during this period. Today, though nothing as spectacular results, I have counted more than 4,000 birds feeding in an area of less than a square mile on the north end of Simpson's Bay. On October 4, 1951, Hochbaum and

Gabrielson made an aerial survey of the Delta marsh for the Manitoba Game Branch; on the west half they estimated there were 3,400 coots to 8,400 ducks.

October numbers drop suddenly, and after the first week the coot is uncommon at Delta. The last big issue leaves with the tail end of the bluewings, two or three weeks before the frost-flight of mallard and lesser scaup. For example, my field notes show that the 1946 peak was on October 4th when a total of 1,500 birds were present on Cadham Bay. The following morning these were gone, and I saw only three more birds during the balance of the season. Come fair weather or foul, few coots remain at Delta beyond the second week of October. Occasionally one sees a single or small group feeding among the rafts of bluebills. But these, as a rule, are cripples that remain to perish when ice closes the marsh.

At Delta the coot is never heavily shot as a game bird. In the course of checking hunters' bags, 4,923 ducks were examined between 1938 and 1941 (Hochbaum, 1944) without encountering a single coot. Notes of field cooperators at Delta for the autumn of 1946 through 1948 show 7,801 ducks were taken without a single coot in the bag.[1] Similar lack of interest in the species has been found on other Manitoba hunting grounds. For example, the cooperative bag survey captained by A. S. Hawkins showed that hunters at The Pas who had taken 1,329 ducks during the first week of the 1947 season had not bagged any coots. On the Netley marshes, 4,285 ducks were tallied during the 1947 and 1948 hunting seasons, with a total of only 17 coots.

Although not considered a game bird in Manitoba, many coots are shot by hunters as a "warm up" while waiting for ducks. These birds are very seldom retrieved and in traveling through the marsh it is common to see dead coots scattered about. On the opening day of the 1946 season, for example, I counted 15 together where some Nimrod had fired into a flock, and dozens of other dead coots were noted by my associates. Later that day, though we checked more than a thousand ducks coming out of the marsh in hunters' bags we found no coots.

Often hunters who destroy coots in this manner believe they are doing the ducks a service. This attitude stems from past policy in regard to the species. Many sportsmen and some naturalists believed the coot was too abundant and that it contributed a heavy drain on food supplies available to the more desirable ducks. Forbush (1925: 370) tells that "In California, according to Grinnell, Bryant and Storer, coots are so numerous still that they are a nuisance on the pre-

[1]Presented in manuscript reports by Lyle K. Sowls, Delta Waterfowl Research Station; A. S. Hawkins. U. S. Fish and Wildlife Service; William L. Newman, Manitoba Game and Fisheries Branch.

serves of the gun clubs, eating the food provided by the clubs for the ducks, and getting in the way of the shooters. Hundreds, if not thousands, have been killed there merely to get them out of the way. In some localities gun clubs hold what they call a 'mud-hen shoot' on the first day of the open season and 'as many as 5,000 coots have been killed in a day on one preserve in Merced County.' ''

More recently the idea of overabundance in the coot has been nourished by editorials urging gunners to *''Shoot That Coot''* (Holland, 1939), and by articles such as that of Brooks (1941), who advocated: ''If all protection cannot be taken from the Coot—and this is what the situation really demands—at least allow game wardens and other qualifiied persons to kill coots whenever and wherever the circumstances warrant.'' As late as 1943 the Fish and Wildlife Service noted that ''the coot continues to increase and its management may become a serious problem. Sportsmen would help if they would add some of these birds to their bag.''

Natives have always valued the coot as food. Whitney (1903:300) in speaking of the Gulf Coast of Mexico stated: ''The natives regularly salt the flesh for food, preferring to hunt them rather than ducks because of the numbers that can be killed at a shot.'' Forbush (1912:22) noted: ''As the supply of wildfowl was depleted, the settlers began potting coots for food . . .'' In Manitoba, any that are caught during muskrat trapping operations are eaten as food. In the days when the Indians collected waterfowl eggs to eat, they tell me that coot eggs were just as palatable as ducks' and much more readily obtained.

Today when the waterfowl populations are barely keeping abreast of the rise in hunter force, the coot in some regions has earned the status of an important game species. Bellrose (1944:7), speaking of the Grass Lake area in northeastern Illinois, calculated that hunters took 23,800 coots opening day 1942, about 90 per cent of the total population present. The next year he found a similar high kill in that area, with 18,225 coots bagged the first day, or 95 per cent of the birds present.

Other areas, such as the north central states, indicate a growing interest in the coot. Hawkins in compiling the 1948 records of the cooperative bag talley for the Mississippi Flyway noted that out of more than 5,219 coots checked, Wisconsin contributed 5,055. He found also that the ratio of coots to ducks taken in the bag checks for the flyway as a whole was one coot to four ducks.

We are learning that the coot has a more important place in the field than most of us formerly realized. In a relatively short space of time *it has been thrust to the forefront* as a game species, without the protection of low bag limits afforded the ducks. At the same time a drastic decline has been noted in the breeding populations at the Delta Marsh and other Southern Manitoba areas. Why this downward trend? Does the Manitoba decline result from a shift in breeding populations; is it the result of some as yet unmeasured ecological force; or does it stem from a heavy loss to guns? Now that we see the decline once advocated by some naturalists do we think it right and proper for the waterfowl populations as a whole? The answer lies in more intensive ecological study of the species.

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DISCUSSION

MR. BENNETT: Are there any comments on this paper?

Maybe we can get into a good hot discussion here over some point.

MR. GEORGE SAUNDERS (U. S. Fish and Wildlife Service, Atlanta, Georgia): Mr. Chairman, I would like to comment briefly with regard to the coot situation in Mexico.

In past winters, I have had the opportunity to work there for the Service; and, during that time I have been in many of the wintering grounds which the coots use.

As recently as 1946, on the January inventory, we saw several million coots in coastal waters from the Rio Grande south to Central America. Some of the individual rafts we photographed there from the air, which comprised more than 50,000 birds; and, in Laguna de Tamiahua, south of Tampico, conservative estimates, in January 1947, on coots which we saw, ran in excess of two million birds. As regards the shooting of coots down there in that republic, as you may know, the shooting of any game birds, or at least water birds in Mexico, is on a very small scale. The hunters there are meat hunters; and, unless they can get a good deal in exchange for their ammunition, they are not interested in those birds.

But, with the coots, since they can very frequently get twenty or more birds with one shot, they do indulge in that hunting.

But, of course, in the aggregate, the kill of coots in Mexico would be very small because, in all probability, there would be no more than several thousand hunters all over the republic who might go out for coot shooting.

Most of those hunters would be using muzle loaders; and you can well imagine what effect that would have upon the efficiency of that hunting.

In one part of Mexico, on Lake Patzcuaro, in the State of Michoacan, every year, there is a very specialized coot hunt conducted by the Indians. You may have seen a recent ad in some of the sporting magazines which showed the Indian hunters armed with spears, out after, I believe the ad stated, waterfowl.

Actually, those Indians who have hunted waterfowl for centuries stage these drives; they usually form a big circle which may be a mile or two miles in diameter. Then they gradually converge in their dugout canoes on the coots, and what ducks may be with them.

These drives will net several hundred or more birds; but you can imagine again the efficiency of that hunting when they are using these three-pronged spears to do it with.

Of course, in more recent years, since the advent of guns, some of those Indians have obtained muzzle loaders to use for that purpose. But, in times when we have been there and checked over the bag, it usually will run nineteen or so coots for every duck. The ducks were usually ruddies or cinnamon teal.

I think we should keep in mind, with regard to the distribution of the coots, at least in past years, a very large percentage of them wintered in Latin America. It is amazing the large numbers which go there, and also the isolated places in which we find them. We have even seen them on little lakes and volcanic craters higher than ten thousand feet. It is quite apparent that, in their migrations, they spread down all across the republic, and some of them even go as far south as northern South America.

MR. JOHN M. ANDERSON (Port Clinton, Ohio): I would like to ask Peter Ward and/or Bill Kiel, who have both pointed out the decline of the coot in the Mississippi Flyway recently, how much of that decline they attribute to shooting pressure. Has the shooting become a limiting factor, or do you have any banding data to indicate that the mortality rate, compared to, say, the mortality rate of the blue-winged teal, which is a very lightly shot species, and the mallard, which is very heavily shot?

MR. WARD: Do you have anything on banding, Bill?

MR. KIEL: I am sorry to report that no banding data is available; at least it was not available for this report, to portray the migration pattern for the coot, and we do not have the returns to show whether the hunting pressure on the coot has increased or not. Bag statistics do show that the hunting pressure has increased. The trend in the breeding ground was determined, at least in our estimate, accurately only in Manitoba, so possibly the migration moved westward, and perhaps the decline was not really for the whole population. Mr. Ward might have something.

MR. PHILIP DUMONT (U. S. Fish and Wildlife Service): If you had banding data, I would be inclined to doubt it. That is a funny statement to make, but I did quite a bid of banding of coots on Sand Lake Refuge, South Dakota, in the thirties. The recovery pattern from South Dakota showed that the birds migrated across Minnesota, Wisconsin, Illinois, Ohio and Pennsylvania. The obvious thing, of course, is that this is the region in which coots are shot and saved. There are scarcely any recovery records from the south, which is the region which the coot normally follows, as shown by Dr. Saunders' work down there.

I just suggest that as a word of caution to anyone who is working with coots on banding records. It goes through that region where we do save the birds.

MR. BENNETT: Any other comments?

MR. ANDERSON: Would either of these gentlemen hazard a guess as to whether the shooting pressure has taken more than a so-called shootable surplus of coots?

MR. WARD: From the population in Manitoba, it looks that way.

MR. ANDERSON: Do you think shooting is more important, or becomes closer to being a limiting factor, than decrease in habitat?

MR. WARD: I do not think there was that much decrease in habitat in Manitoba last year.

MR. LEACH (Manitoba, Canada): I have done quite a bit of work in Saskatchewan. I am sorry I missed the beginning of Bill's paper, but I cannot give any comparative figures. But, based on general impression in the area in which I am quite familiar, there was a very large increase in the coot breeding population in the last year. That was for southern Saskatchewan.

AERIAL SURVEYS FOR BEAVER IN THE MACKENZIE DISTRICT, NORTHWEST TERRITORIES

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The purpose of this paper is to describe the methods used in making extensive aerial surveys for beaver in wilderness areas and to indicate briefly what types of results are obtained and how they may be used.

The beaver (*Castor canadensis*) still occupies an important place in the economy of the aborigines (Indians and Eskimos) of the Mackenzie District, Northwest Territories, and accordingly, new or improved methods of beaver management are constantly being sought. Knowledge of the distribution and abundance of the beaver is considered to be of prime importance in establishing seasons and regulating harvests. The area of the Mackenzie District is 527,000 square miles, of which about 300,000 square miles are south of timberline. Ground transportation in the area is slow, and the airplane was the only possible way in which adequate coverage could be obtained.

The first experiments with aerial surveys were carried out in 1947 and 1948. The object of these early surveys was merely to locate areas in which the beaver population was depleted. In 1949, Kelsall (unpublished report in the files of the Canadian Wildlife Service) attempted to locate and plot the active colonies in two areas in the southern part of the Mackenzie District. Kelsall's basic methods have been extended and refined during subsequent surveys in 1951 and 1952. The writer is indebted to D. R. Flook and E. H. McEwen of the Canadian Wildlife Service who have taken part in aerial surveys and contributed to the development of the techniques employed.

OBJECTIVES

The two major objectives of the surveys were: (1) To examine all parts of the Mackenzie District and evaluate the quality of beaver habitat; (2) to develop an index of abundance which can be used either to compare the beaver populations of different areas, or to follow

[1]In the absence of the author this paper was read by Dr. V. E. F. Solman, Canadian Wildlife Service.

the trends in the beaver population of a given area over a period of time.

METHODS

Before describing methods in detail, it is necessary to point out certain difficulties which were encountered. First, because of the great size of the area, the coverage had to be extensive rather than intensive. Second, as many of our flights exceeded the normal range of the light aircraft used, it was necessary to carry gasoline and oil in the cabin of the airplane. Certain areas, *e.g.*, the north shore of Great Bear Lake, could not be reached even then because gasoline caches are few and widely scattered in that area. Third, the standard map sheet is on a scale of eight miles to one inch. Although the general quality of these maps is good, it is impossible to portray the smaller features accurately on this scale. Finally, there is a scarcity of physiographic data for this entire area. Few elevations and no contours are shown on the standard maps, and the personal knowledge of the investigators is therefore important.

The method of surveying consists in flying along a prearranged route with an observer on each side of the aircraft recording in a notebook all evidence of the presence of beaver. Parallel columns are ruled on a page in the notebook and head: "Time, Feed Beds, Lodges, Dams, Runways, Remarks." For each observation, the time is recorded to the nearest minute and then a stroke is entered in the appropriate column. Where two or more beaver "signs" are obviously associated—for example, a feed bed[2] in front of a lodge—the observations are entered in the same line. However, if the "signs" are not related—for example, a lodge in each of two adjacent lakes—each is entered on a separate line in the notes. Whenever large, easily identified landmarks are passed, the time is recorded and the nature of the reference point is entered in the Remarks column. Brief notes on topography, vegetation, recent fires, or other observations of possible significance are also made from time to time. Table 1, which contains part of a specimen page from the field notes, will help to clarify the method.

Flight lines are plotted to sample the greatest amount and variety of beaver habitat in the area to be covered. Where the beaver habitat consists mainly of streams, a number of these are followed, and the course is planned in such a way that unproductive travel between watersheds is kept to a minimum. The pilot is instructed to fly along one side of the stream so that one observer devotes his full attention

[2]This is the term applied almost universally by trappers in the Northwest Territories to the mass of sticks which the beavers store up in advance for winter use. The term is used throughout this paper.

TABLE 1. EXTRACT FROM FIELD NOTES FOR 19 SEPTEMBER, 1952, TO ILLUSTRATE THE METHOD OF RECORDING OBSERVATIONS.

Time	Feed Beds	Lodges	Dams	Runways	Remarks
1438					Crossed Yukon-N.W.T. boundary
40	1	1			
41		1	1	1	
42	1				
			1	1	
43		1			} In same lake.
		1			
		1			In a small lake.
		1			In a small lake.
					Picked up small creek leaving lake. Good
44		1			habitat. Bordered by willows therefore
		1			visibility good. Broad valley.
45			1		
			1		
	1		1		

to the stream while the other observer views some of the tributaries, and usually, a number of small lakes which lie along the course. Following the main stream requires the intense concentration of the observer which produces fatigue. When this occurs, the pilot shifts the aircraft to the other side of the stream, which reverses the tasks of the observers.

A course such as this can be followed accurately and reflown in a similar manner in subsequent surveys.

Where the beaver habitat consists mainly of lakes, the same method will often succeed. Sometimes, however, the lakes are so numerous that they cannot all be portrayed on the map, and as individual lakes cannot be identified it is impossible to follow a prearranged route. To avoid this difficulty a technique is being developed whereby an attempt is made to fly along a straight line between recognizable points. At the same time the proportion of lakes occupied by beaver is noted.

The altitude at which the surveys are carried out varies with conditions. Stream courses are usually followed from an elevation of 500 to 800 feet above the ground. When flying over lake country, however, it has been found that beaver "sign" is easily seen from an elevation of 2,500 feet.

DISCUSSION OF METHODS

Swank and Glover (1948) and Crissey (1949) apparently plotted their observations directly on large-scale maps of the areas in West Virginia and New York, respectively, which they surveyed. This was tried in the Northwest Territories and discarded in favor of the method described for two reasons. First, the standard maps show insufficient detail, and second, detailed map reading requires the observer to divide his attention between the map and the ground and may result in beaver "sign" being overlooked. Map reading is, therefore, left to the pilot who follows the flight line marked on the map, informs the observers of their position on request, and points out prominent landmarks as they are passed.

An examination of Table 1 will show that the field notes may be readily converted into the number of colonies seen. With few exceptions, each line in the notes represents a separate colony. The decision whether two or more observations represent one colony, or more than one, must be made at the time and entered in the notes accordingly. Plotting colonies directly on the map does not relieve the investigator of the responsibility of making similar decisions.

The colony is the unit of beaver management in the Northwest Territories. Each trapper is entitled to trap, each year, a number of beavers not to exceed the number of beaver colonies in his area. For this reason all census figures are shown as the number of colonies seen, and no attempt is made to estimate the total number of beavers they represent.

One problem, which is always present when taking a census of beavers, is how to allow for "bank beavers" that live in burrows in the stream bank and do not build lodges. This difficulty has been partly overcome by delaying all survey flights until after September 15. By this date most of the beavers are at work accumulating their winter food supply. These feed beds, or storage piles, are easily seen from the air and are taken as certain evidence of the presence of a beaver colony. Crissey (*op. cit.*) utilized this fact in making a beaver census in New York. Swank and Glover (*op. cit.*) carried out their census in April when feed beds were used up or carried away by spring freshets. They considered that late autumn, after the leaves had fallen, would be a better season for taking a census because of increased visibility, but they apparently overlooked the more important factor of the presence of winter food.

In certain cases, it is difficult to distinguish between an active and an inactive lodge when flying over them. If a feed bed is present, all doubt is removed. Occasionally, also, a single colony of beavers will maintain more than one lodge, but a single feed bed is the rule.

There are two theoretical advantages to using the proportion method of surveying the type of beaver habitat that consists mainly of lakes. First, it is highly improbable that a pilot could fly a course exactly as marked with an inadequate map as a guide, or that he could duplicate the transect exactly at another time. Thus, the actual lakes seen may not be identical from one survey to the next. Provided, however, that the sample strips are representative of the area as a whole, and are adequate in size, it is thought that a change in the proportion of lakes occupied will be a valid indicator of a change in the beaver population, even though the transects are not duplicated exactly.

Second, the proportion method eliminates two interrelated variables which are otherwise difficult to control—elevation above the ground and width of strip. An observer flying high can cover a wider strip and survey more lakes than one flying low, but the ratio of occupied to unoccupied lakes seen by each should be the same.

RESULTS

Evaluation of habitat. A few generalizations may be made at this time regarding grades of beaver habitat. The Slave-Liard-Mackenzie River system flows through a level plain known as the Mackenzie Lowlands, which are considered to be a northern extension of the Great Central Plains. In general, the Mackenzie Lowlands contain much favorable beaver habitat. To the east lies the Laurentian Plateau, composed of Precambrian rocks. The topography of the plateau is typically rugged, and conditions have not favored the formation or accumulation of soil or the development of forest growth, particularly of the deciduous species. The beaver potential is therefore low. Along the western boundary of the plateau, however, there is a zone of variable width where some soil has accumulated and where deciduous trees are reasonably numerous. There are some surprisingly large beaver populations in this narrow zone.

West of the Mackenzie Lowlands lies the Cordilleran Plateau. No surveys have been carried out in this mountainous region as yet.

The index of abundance. Several uses of the index of abundance are suggested by the results of surveys in the Fort Providence area in 1949 and 1951, and in the Fort Smith area in 1949 and 1952. Pertinent data are recorded in Table 2.

The beaver population in the Fort Providence area was depleted in the early 1940's by a combination of destructive forest fires and heavy trapping pressure. Beavers were given year-round protection by law in 1945. Trapping was permitted again in 1952. Both surveys were conducted during the period when there was no legal trapping of beavers.

Two of the major streams in the area, the Redknife River and the south fork of the Kakisa River, showed no apparent increase between 1949 and 1951. It is concluded therefore that their beaver populations were at saturation levels in 1949, and that the annual increment probably left the parent streams to repopulate tributaries and other connected waterways. The indices of abundance were found to be 1.4

TABLE 2. A COMPARISON OF BEAVER "SIGNS" OBSERVED ON SUCCESSIVE SURVEYS IN TWO AREAS IN THE SOUTHERN PART OF MACKENZIE DISTRICT. THE INITIAL SURVEY IN EACH AREA WAS CARRIED OUT IN 1949. THE FORT PROVIDENCE AREA WAS RE-SURVEYED IN 1951 AND THE FORT SMITH AREA IN 1952.

Drainage	Distance Surveyed (miles)	First Survey Feed Beds	First Survey Dams	Second Survey Feed Beds	Second Survey Dams	Apparent Trend
Fort Providence Area						
1. Tributary of Kakisa River from the west	18		15	19	31	X2
2. South fork of upper Kakisa River	32		33	29	29	....
3. Stream entering southwest corner of Tathlina Lake	16		1	8		X8
4. Streams entering Kakisa Lake from southeast	32		12	15	27	X2
5. Stream entering southeast corner of Tathlina Lake	13	6	11	11	12	X2
6. Redknife River	50		48	30	44	....
7. Laferte River	68		20	15	53	X2
8. Tributary of Kakisa River from Cameron Hills	29		6	9	12	X2
9. Swede Creek	41		2	9	14	X7
Subtotal	299	6	148	145	222	
Fort Smith Area						
10. Tsu Lake to Jack Lake	53	3	1	12	9	X4
11. Jack Lake to Methleka Lake	14	8	4	16	8	X2
12. Thubun Lake to Rocher River	70	4	5	15	6	X2
Subtotal	137	15	10	43	23	

colonies per mile on the Kakisa and 1.0 colonies per mile on the Redknife. Until further evidence is obtained, we are assuming as a hypothesis that any value in excess of 1.0 colonies per mile, as determined by the aerial method, represents a saturated population.

The highest index so far obtained in lake country is 1.4 colonies per mile, which is well above saturation level. This was achieved on a transect on which the proportion of occupied lakes was 46.7 per cent. On the basis of this evidence, it is thought that about 50 per cent occupancy of lakes, as determined by the aerial method, may represent a saturated population in lake country.

The rate of increase in an unexploited beaver population is also indicated in Table 2. Of five drainages in the Fort Providence area, which apparently contained a fair residue of beaver in 1949, the amount of beaver "sign" observed doubled in two years. On two streams, which were practically devoid of beaver in 1949, explosive increases of seven- or eight-fold were noted. These streams were probably the recipients of surplus beavers from such saturated streams as the Kakisa and Redknife.

On three transects in the Fort Smith area, the amount of beaver "sign" observed approximately tripled in three years, in spite of a limited amount of trapping in the third year (spring of 1952).

It is apparent from the foregoing that beaver can increase and spread at a rapid rate.

One further interesting use of the survey data might be cited. Fairly extensive surveys were carried out in the lower Mackenzie River basin. A part of the area surveyed was set aside in 1939 as a beaver preserve known as the Mackenzie Delta Beaver Sanctuary and has been closed to the hunting of beaver ever since. Flights totalling 170 miles were made over various parts of the Sanctuary, and 109 colonies were seen. These yield an index of 0.6 colonies per mile. Outside the Sanctuary, where trapping pressure has been continuous, 235 miles were surveyed and 72 colonies seen for an index of 0.3 colonies per mile. The Sanctuary does not differ essentially in environmental conditions from the remainder of the area. It is concluded, therefore, that the areas open for the trapping of beaver are not at present populated to capacity.

SUMMARY

The beaver is one of the most important fur-bearing mammals in the Mackenzie District. Knowledge of its distribution and abundance is considered basic to good management. Such knowledge can only be obtained in this immense wilderness area with the aid of the airplane.

A technique of aerial surveying is described. All beaver "signs" are noted and used, but greatest reliance is placed on locating the winter feed beds which are taken as certain evidence of the presence of beavers.

The results obtained from aerial surveys in 1949, 1951, and 1952 have been used to map three grades of beaver habitat. An index of abundance (colonies per mile) has been used to identify saturated habitats, to study the rate of population gain, and to demonstrate the beneficial effects of a sanctuary.

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DISCUSSION

DR. ARNOLD B. ERICKSON (Minnesota): In the winter of 1951 and in the spring of 1952, we had a very extensive die-off of the beaver in Minnesota, due to disease. We did not realize how extensive that was until trapping began in April of 1952. Then we found beaver dead in the lodges, floating around the streams and the lakes. We received them at the veterinary laboratory, University of Minnesota, and we sent others to the Hamilton Spotted Fever Laboratory in Montana. They were not able there to isolate tularemia, nor were we in Minnesota; so, to date, we do not know what caused that die-off. However, we believe we lost around 8,000 beaver that spring.

I wonder if you have had any recent experience with disease in beaver in the Mackenzie District.

DR. SOLMAN: Fortunately, no. There has been the odd isolated case of an animal being found dead, one or two a winter, that sort of thing; but no major loss of any kind in this area. I say "fortunately," because in this area, beaver trapping is one of the important sources of income of the native population. We are alert to the possibility of disease, and hope that, if we are faced with an outbreak, we can learn what it is and attempt to control it before it spreads too far. So far, we have not had that difficulty.

DR. CARL L. HUBBS (Scripps Institution of Oceanography, LaJolla, California): I would like to ask, have you tried out any of these light-weight tape or wire recorders as an aid in getting your information down? With that, perhaps, you will not even have to make notes on your paper, if you talk fast enough.

DR. SOLMAN: We have used that quite extensively in waterfowl work, and we just have not gotten around to moving any of that equipment up into this area yet. That, I think, will be one of the next developments. We are quite impressed with what you can do with that type of recording.

CHAIRMAN CAMPBELL: I should like to thank each of the speakers for their contribution this afternoon, and to thank George Bennett who has acted as the session leader.

This terminates the afternoon program.

Thank you.

TECHNICAL SESSIONS

Tuesday Morning—March 10

Chairman: ARNOLD B. ERICKSON
Game Research Supervisor, Department of Conservation, St. Paul, Minnesota

Discussion Leader: PHIL GOODRUM
Biologist, Research Division, U. S. Fish and Wildlife Service, Atlanta, Georgia

SMALL-GAME RESOURCES

A PRELIMINARY EVALUATION OF CRIPPLE LOSSES IN WATERFOWL

FRANK C. BELLEROSE[1]
Illinois Natural History Survey, Havana, Illinois

There are many unknowns and near unknowns among the mortality factors affecting waterfowl, and crippling, though a man-made cause, is one of them. The number of ducks knocked down but unretrieved, as determined by interviewing hunters, is a phase of the crippling problem which has received considerable attention. Otherwise, this mortality factor remains relatively unexplored. Increased attention to the following is especially desirable: The proportion of knocked-down cripples that recover; the proportion of fatally injured birds that fail to fall within view of the hunter; the effect of "dusting" wherein feathers fly at the shot but the bird continues apparently uninjured.

The problem of measuring crippling losses and determining their cause is so diverse and complex that this paper represents only a bare beginning: An attempt to tie loose ends together to form a more complete picture of waterfowl crippling losses. Our approach is fourfold:

1. Compile the available data on the relative numbers of ducks which are knocked down but unretrieved by hunters.

[1]Olin Industries, Inc., cooperating.

2. Examine live-trapped ducks by X-ray to determine the incidence and importance of flesh and internal shot wounds.

3. X-ray and autopsy incapacitated ducks collected during and immediately following the hunting season to determine the cause of their affliction.

4. Examine bagged ducks by X-ray to determine the extent and nature of their wounds.

KNOCKED-DOWN BUT UNRETRIEVED LOSS

Hunters differ in their interpretation of what constitutes a crippled duck; some classify every duck hit but unretrieved as a cripple, others only those knocked down but unretrieved. As a means of overcoming the variations in individual opinion, it is a standard practice for biologists to request the number of knocked-down but unretrieved ducks in addition to the number bagged. The reliability of these data depends largely upon the integrity and the awareness of the individual hunter. Memory is less important because the daily bag is low and the interview occurs immediately following the hunt. There is reason to believe that only a relatively few hunters are so chagrined at a high cripple loss as to minimize their lack of success in bagging ducks.

The degree of the loss from felled but unretrieved ducks depends upon a number of conditions, the more important among them being: Species of duck, type of habitat, use of a retriever, competition between hunters, and the skill of the individual hunter.

The type of habitat proved important in determining the fate of downed ducks. Much more difficulty was experienced in finding felled ducks in marshes or swamps with dense cover than where open water prevailed. For example, dense cover contributed to the above average loss of downed ducks at the Rice Lake and Batchtown Refuges in Illinois and at Reelfoot Lake in Tennessee (Table 1). At the Rice Lake Refuge, extensive beds of river bulrush (*Scirpus fluviatilis*) were responsible; at the Batchtown Refuge, dense beds of marsh smartweed (*Polygonum muhlenbergii*); and at Reelfoot Lake extensive beds of giant cut-grass (*Zizaniopsis miliacea*).

In dense cover a crippled duck that is not dead or in a severe state of shock has a good opportunity to escape unless a retriever is used. Many ducks are brought down solely by the breaking of a wing; shock is light and the birds are able to swim almost immediately after hitting the water. Because of differences in the habitat frequented, dabbling ducks are more likely to be downed in heavy cover than diving ducks; therefore, marsh and swamp shooting results in heavy losses among the dabbling species of ducks.

TABLE 1.—THE NUMBER OF DUCKS BROUGHT TO BAG AND UNRETRIEVED AMONG BIRDS KNOWN TO HAVE BEEN KNOCKED DOWN BY HUNTERS IN VARIOUS AREAS OF THE UNITED STATES UNDER SEVERAL TYPES OF HUNTING.

Period	Place	Authority	Type of hunting	Predominant	Ducks knocked down by hunters		
					No. bagged	No. unretrieved	Per Cent unretrieved
1945-1949	Pointe Mouille, Michigan	H. J. Miller (1950)	Public shooting marsh	dabbling ducks	21,837	6,820	23.8
1946-1950	Horicon Marsh, Wisconsin	R. C. Hopkins (1947, 1948, 1949, 1950, 1951)	Public shooting marsh	dabbling ducks	9,234	3,201	25.7
1949-1950	Lake Puckaway, Wisconsin	R. C. Hopkins (1951)	Public shooting	dabbling and diving ducks	479	117	19.6
1949-1950	Miss. River, Wisconsin	R. C. Hopkins (1951)	Public shooting	dabbling ducks	7,714	1,253	14.0
1949-1952	Miss. River, Illinois	George Arthur	Private clubs open water	mallards and diving ducks	2,026	528	20.7
1950	Batchtown, Illinois	George Arthur	Public shooting marsh	mallards and pintails	675	450	40.0
1944-1945	Rice Lake, Illinois	F. X. Leuth	Public shooting marsh	dabbling ducks	2,985	1,168	28.1
1938 and 1941	Illinois River, Illinois	F. C. Bellrose	Private clubs lake and marsh	mallards	5,254	937	15.1
1951	Reelfoot Lake, Tennessee	C. K. Rawls (1952)	Public shooting marsh and swamp	mallards and ring-necked ducks	7,864	2,971	27.4
1950-1951	Various areas, South Dakota	M. E. Anderson (1952)	Public shooting	dabbling ducks	2,321	751	24.4
1949-1951	Coastal marshes, Delaware	E. B. Chamberlain (1952)	Public shooting	dabbling ducks	3,824	452	10.6
				Total	64,213	18,648	22.5

In shooting over open water, however, diving ducks which have been knocked down are more likely to escape than dabbling ducks. Records from clubs on the Mississippi River in Illinois show a greater crippling loss than those from Illinois River clubs (Table 1); this is in consequence of the larger proportion of diving ducks frequenting the sector of the Mississippi River from which the records were obtained. At the Delta Marsh, Manitoba, one crippled diving duck is lost for every one bagged (Hochbaum 1947). This extremely high loss probably results from the dense marsh cover characteristic of the region.

Diving ducks that are hit but not seriously wounded use their diving ability to make a more difficult, elusive target than a dabbling duck. Especially in rough water, the split-second emergence of a diving duck's head lessens the opportunity for firing a lethal shot. It has been suggested by many experienced hunters that diving ducks are less susceptible to shock than dabbling ducks.

The conduct of the hunter in the field bears a close relationship to crippling losses. Competition between hunters results in more shooting at long ranges, which, in turn, increases the number of ducks that are unretrieved. Competition among hunters reaches its zenith on those public shooting grounds where numbers of hunters are unrestricted. The hunter who uses good judgment in estimating range and lead and is adept at aligning his gun on the target produces fewer cripples than the less skillful hunter. Even experienced hunters shooting under the most favorable conditions, however, never retrieve a proportion of the ducks known to have been brought down. At private duck clubs in the Illinois River Valley, where hunters are above average in experience, where guides are employed to aid the shooter in decoying and retrieving downed ducks, and where competition for targets is practically nil, the ducks unretrieved still amounted to 15.1 per cent (Table 1).

Elsewhere in the United States reported crippling losses generally have been higher than those for the Illinois River Valley because more of the factors producing cripples are operative in those areas. Records from public shooting grounds, of course, show the greatest loss in unretrieved ducks. Add dabbling-duck shooting in dense cover or diving-duck shooting and the total loss increases.

The knocked-down but unretrieved duck loss, as reported from many sections of the United States, averaged 22.5 per cent. This probably represents a minimum knocked-down loss of ducks because of the failure of hunters to see some of the ducks fall, and also because of the known (but believed to be slight) tendency of hunters to minimize high crippling losses. Even though the reported knocked-down but unretrieved loss in ducks does not constitute the total crippling loss, it does form a framework upon which the evaluation of other cripple losses can be appended.

DUCKS HIT BUT NOT DOWNED

In addition to the loss of downed ducks which hunters fail to retrieve, there is an unknown loss among those ducks which are hit but continue to fly for such a distance that they are not classified as lost birds. It is possible to obtain some information on the extent and nature of wounds in such birds by fluoroscoping ducks which are being live-trapped during the hunting season. It is also possible to determine the importance of shot wounds in live-trapped ducks. However, there is one weak link in this chain of data—the unknown loss that occurs between the time a duck is hit, but continues in flight, and the time it is live-trapped.

Shot pellets found lodged in the tissues of ducks are indicative of shot wounds. Such shot is generally referred to as "body" or "embedded" shot. Shot may also be present in the digestive system as a result of swallowing pellets picked up in feeding activities. Such shot is generally referred to as "gizzard" or "ingested" shot. Shot pellets are readily discernible on the fluoroscopic screen, and their location can be determined in relation to the soft-hard tissues of the body.

The fluoroscope was first used to determine the incidence of embedded and ingested shot pellets by Whitlock and Miller (1947). Elder (1950) described the use of a field unit—consisting of a portable X-ray, blackout tent, and electric generator—for determining occurrence of lead shot in ducks. Jordan and Bellrose (1951) have reported on the technique of using the fluoroscope to obtain the data presented in this paper. Of special note was the use of a fiber cone to hold the duck suspended on a cradle between the X-ray head and the fluoroscopic screen (Fig. 1). By rotating the cone back and forth it was possible to determine the location of a shot pellet from two or more planes; this was especially helpful in locating shot within the body cavity or in the body wall. Shot pellets were recorded by topographic regions of the body and whether within the body cavity or skull or in the flesh.

The proportion of blue-winged teals, wood ducks, and pintails with shot wounds is presented in Table 2. These ducks were live-trapped in advance of the hunting season in Illinois, so the incidence of shot wounds was at a minimum for this area. The difference in the proportion of adults and juveniles with shot wounds is indicative of the carry-over of embedded shot in the adults from previous hunt-

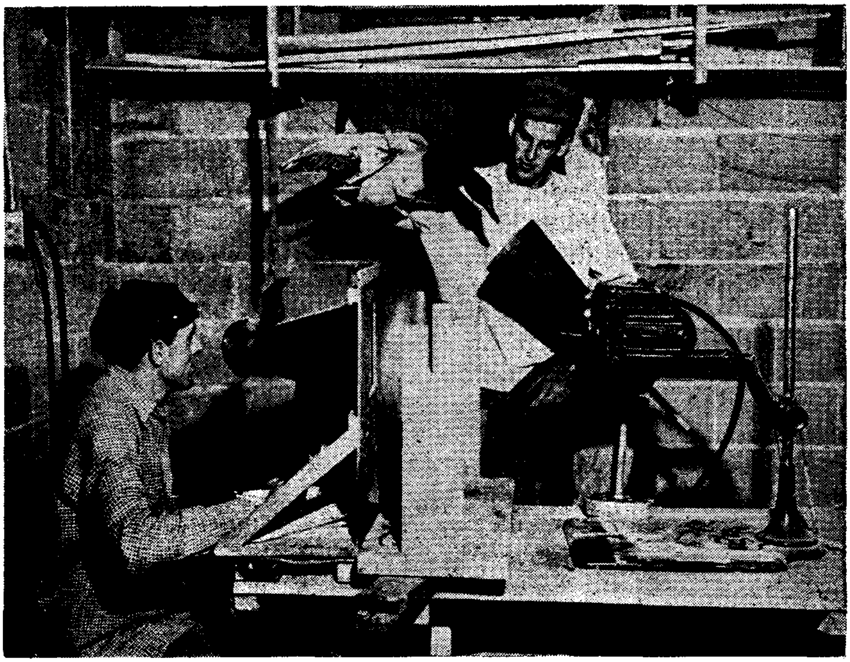

Fig. 1. The fluoroscope was used to determine the extent and nature of shot wounds in ducks.

ing seasons. Thus, approximately 8 per cent of the adult blue-winged teals, 8 per cent of the adult wood ducks and 12 per cent of the adult pintails had been hit by one or more shot pellets, but still survived to reach Moscow Bay before the season in Illinois opened.

The incidence of embedded shot in adult blue-winged teal in Illinois was similar to that found by Elder (1950) in birds fluoroscoped in Manitoba and Saskatchewan during the summers of 1948 and 1949. Elder reported a much higher proportion of pintails with shot lodged in tissues, which may indicate that the early group of pintails migrating into Illinois is a "traditional" one which, by its early flight, experiences less shooting pressure.

TABLE 2.—THE OCCURRENCE OF EMBEDDED SHOT PELLETS IN THREE SPECIES OF DUCKS LIVE-TRAPPED IN SEPTEMBER AND EARLY OCTOBER AT MOSCOW BAY, NEAR BATH, ILLINOIS, 1949-1951.

	Adults		Juveniles	
Species	No. examined	Per cent with shot	No. examined	Per cent with shot
Blue-winged teal	260	7.7	1,656	0.8
Wood Duck	308	8.4	340	2.4
Pintail	66	12.1	87	1.1

TABLE 3.—OCCURRENCE OF SHOT PELLETS EMBEDDED IN TISSUE OF MALLARDS LIVE-TRAPPED AT THE CHAUTAUQUA NATIONAL WILDLIFE REFUGE, ILLINOIS, 1949. THE HUNTING SEASON WAS FROM NOVEMBER 4TH THROUGH DECEMBER 13.

Period	Adult Drake			Juvenile Drake		
	No. checked	No. with shot	Per cent with shot	No. checked	No. with shot	Per cent with shot
Oct. 26-30	68	29	42.6	34	5	14.7
Oct. 31-Nov. 4	102	41	40.2	61	8	13.1
Nov. 5-9	118	44	37.3	42	3	7.1
Nov. 10-14	134	45	33.6	58	6	10.3
Nov. 15-19	238	89	37.4	88	8	9.1
Nov. 20-24	371	127	34.2	14	2	14.3
Nov. 25-29	311	112	36.0	38	6	15.8
Nov. 30-Dec. 4	149	49	32.9	1	0	....
Dec. 5-9	168	53	31.5	106	25	23.6
Dec. 10-24	80	37	46.2	50	14	28.0
TOTALS	1,739	626	36.0	492	77	15.7

The seasonal distribution of shot lodged in the tissues of mallards live-trapped at the Lake Chautauqua National Wildlife Refuge during the falls of 1949 and 1950 (Tables 3 and 4) shows that those arriving in Illinois before the season opened had as high a proportion of body shot as birds which experienced local shooting pressure. The lack of a build-up in the proportion of body shot is indicative of a constant turnover in this duck population. The last flight of mallards, a large portion of which normally winters, shows a higher ratio of wounded birds than did earlier groups.

Over a period of years, the yearly variation in mallards with body shot was considerable, but much of this resulted from inadequate samples, especially those taken at Spring Lake, 1946-1948 (Table 5). A mean of all data showed adults had been wounded about twice as frequently as juveniles. Evidently this resulted from a carry-over of embedded shot from previous hunting seasons. The high proportion of flying mallards which have been hit by shot pellets attests to the

TABLE 4.—OCCURRENCE OF SHOT PELLETS EMBEDDED IN THE TISSUE OF MALLARDS LIVE-TRAPPED AT THE CHAUTAUQUA NATIONAL WILDLIFE REFUGE, ILLINOIS, 1950. THE HUNTING SEASON WAS FROM NOVEMBER 3 THROUGH DECEMBER 7.

Period	Adult Drake			Juvenile Drake		
	No. checked	No. with shot	Per cent with shot	No. checked	No. with shot	Per cent with shot
Oct. 31-Nov. 4	112	30	26.8	15	4	26.7
Nov. 5-9	313	122	39.0	54	15	27.8
Nov. 10-14	249	65	26.1	147	25	17.0
Nov. 15-19	222	82	36.9	162	19	11.7
Nov. 20-24	124	57	46.0	191	37	19.4
Nov. 25-29	76	28	36.8	73	13	17.8
Nov. 30-Dec. 24	90	54	60.0	60	29	48.3
TOTALS	1,186	438	36.9	702	142	20.2

TABLE 5.—THE OCCURRENCE OF EMBEDDED SHOT PELLETS IN MALLARDS LIVE-TRAPPED DURING THE FALL AT THE SPRING LAKE NATIONAL WILDLIFE REFUGE, 1946-1948, AND THE LAKE CHAUTAUQUA NATIONAL WILDLIFE REFUGE, 1949-1952.

	Adult Drakes		Juvenile Drakes		Hens	
Year	No. examined	Per cent with shot	No. examined	Per cent with shot	No. examined	Per cent with shot
1946	41	41.5	54	27.8	36	44.4
1947	61	36.1	70	5.7	82	9.8
1948	113	29.2	132	15.1	77	11.7
1949	1,739	36.0	492	15.6	141	22.0
1950	1,186	36.9	702	20.2	183	24.0
1951	119	38.6	132	21.2	35	22.9
1952	82	40.2	36	16.7	58	25.9
Totals	3,341	36.4	1,618	18.0	612	21.4

large proportion of ducks which hunters hit but which continue in flight.

During the summers of 1948 and 1949, Elder (1950) fluoroscoped mallards for the incidence of body shot. At the two areas in Manitoba where his study was made, he found that at one area, 31.9 per cent of the adult drakes contained body shot whereas at the other area 27.5 per cent had body shot.

Mallards wintering at two lakes in South Dakota were checked for the occurrence of body shot. According to Murdy (1952), 31.5 per cent of the drakes sampled at Lake Andes had body shot, and 27.3 per cent of the drakes at Coxy's Lake contained embedded shot. Wintering mallards were fluoroscoped for body shot (Poley, 1951) in Colorado where 13.7 per cent of the drakes were found to contain shot in 1950, while in 1951 the proportion with body shot increased to 18.1 per cent. However, it is evident that the mallards in Colorado faced considerably less shooting pressure than did those sampled in Illinois and South Dakota.

The frequency of shot wounds among mallards live-trapped in Illinois is shown in Table 6 and Figure 2. There is a tendency for

TABLE 6.—THE FREQUENCY OF BODY SHOT IN ADULT AND JUVENILE DRAKE MALLARDS LIVE-TRAPPED AS FLYING BIRDS AT THE CHAUTAUQUA NATIONAL WILDLIFE REFUGE, 1949 AND 1950.

Number of	Number of ducks		Per cent of ducks	
shot wounds	Adult drake	Juvenile drake	Adult drake	Juvenile drake
1	590	145	49.5	55.3
2	268	66	22.5	25.2
3	132	26	11.1	9.9
4	84	14	7.0	5.3
5	52	6	4.4	2.3
6	24	2	2.0	0.8
7	18	1	1.5	0.4
8	9	1	0.7	0.4
9	7	0	0.6	0.0
10 and over	9	1	0.7	0.4
TOTALS	1,193	262	100.0	100.0

TABLE 7.—CLASSIFICATION OF SHOT PELLETS FOUND LODGED IN VARIOUS PARTS OF THE BODY IN MALLARDS LIVE-TRAPPED AT THE CHAUTAUQUA NATIONAL WILDLIFE REFUGE, 1949 AND 1950.

Part of Body	External shot		Internal shot		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Bill	27	1.0	0	....	27	1.0
Head	110	3.9	9	0.3	119	4.2
Neck	281	9.9	1	....	282	9.9
Chest	105	3.7	9	0.3	114	4.0
Breast	295	10.4	28	1.0	323	11.5
Belly	264	9.3	114	4.0	378	13.4
Side	289	10.2	11	0.4	300	10.6
Flank	137	4.8	4	0.1	141	5.0
Thoracic back	274	9.7	32	1.1	306	10.8
Caudal back	289	10.2	34	1.2	323	11.4
Wing	332	11.7	7	0.2	339	12.0
Leg and foot	172	6.1	3	0.1	175	6.2
TOTALS	2,575	91.9	252	8.9	2,827	100.0

the adults to carry a higher number of shot wounds. Undoubtedly the reason for this greater number of shot wounds among the adults is the result of wounds from previous years. It is important to note the relatively small proportion of live-trapped mallards that contained over three shot wounds.

A rather arbitrary classification of the location of embedded shot among 1,358 live-trapped mallards in which fluoroscopy revealed body shot is given in Table 7. A shot pellet was classed as internal if it was lodged within the body cavity, the brain cavity, the vertebral column, or if a leg or wing bone was fractured. A shot pellet was classed as external if it was lodged in the skin or flesh.

As shown by Table 7, most of the shot pellets were found in external parts of the body, with only about 9 per cent embedded in internal tissues. Many of the pellets found in the breast or side were lodged against the sternum, which, evidently, had stopped these pellets from penetrating into the body cavity. An exceptionally large number of shot pellets was found within the body cavity in the belly area; most of these pellets had lodged in the muscle of the gizzard, which lies directly dorsal to the abdominal wall. Of the 28 shot pellets found internal in the breast area, eight were in or so near the heart that they oscillated with each heart beat. It is apparent that only a small proportion of the fractured bones in wild ducks mend successfully. Only seven of the 4,443 mallards examined in 1949 and 1950 were observed to have healed wing fractures, but admittedly, bones with slight fractures may have been overlooked. Whitlock and Miller (1947) found 19 ducks with healed wing fractures out of about 900 fluoroscoped in Michigan.

What effect does the body shot found in live-trapped mallards have on their well-being? If the wounds had a deleterious effect, it would

TABLE 8.—THE WEIGHT OF ADULT AND JUVENILE DRAKE MALLARDS GROUPED AS TO THOSE WITHOUT BODY SHOT AND BY THE NUMBER OF SHOT PELLETS LODGED IN THEIR BODIES, LAKE CHAUTAUQUA, 1949 AND 1950. FIGURES IN PARENTHESES REPRESENT THE NUMBER WEIGHED.

Year	0 shot	1 shot	2 shot	3 shot	4 shot	5 shot
	Adult Drakes					
1949	2.67 (914)	2.67 (268)	2.69 (116)	2.61 (55)	2.75 (37)	....
1950	2.68 (882)	2.67 (256)	2.64 (135)	2.57 (55)	2.66 (40)	2.62 (22)
Average	2.68 (1796)	2.67 (525)	2.67 (251)	2.59 (110)	2.70 (77)	2.62 (22)
	Juvenile Drakes					
1949	2.42 (248)	2.31 (24)	....	....		
1950	2.35 (487)	2.26 (60)	2.47 (29)	2.32 (22)		
Average	2.39 (735)	2.29 (84)	2.47 (29)	2.32 (22)		

be most serious because of the large proportion of wild ducks so afflicted. To appraise the significance of these shot wounds, we have resorted to three methods: (1) Body weight, an index to the health of birds, was recorded for mallards with and without body shot; (2) ducks with apparently serious but not debilitating internal shot wounds were confined in pens along with shot-free birds as controls; (3) band returns from ducks with body shot and without body shot at the time of banding were compared to determine subsequent survival.

The weights of mallards without body shot are compared to the weights of those with body shot in Table 8. The variation in the weights between mallards without wounds and those carrying one or more body shot is so slight as to be insignificant. To the extent that body weights serve as criteria of condition, it seems evident that the embedded shot pellets had very little net effect on the well-being of live-trapped mallards. It should be noted, however, that there were nine live-trapped mallards which were unable to fly because of fractured wings.

A sample of live-trapped mallards afflicted with body wounds were placed in pens along with a sample of ducks free of body shot; these were used as controls. Of the 76 penned mallards with wounds 22 died within a 100-day period as compared to 28 of the 82 controls. Wounded ducks that died lived an average of 62 days; control birds that died lived an average of 58 days. In view of later experience, it seems probable that deaths in both groups were induced by the straight diet of corn. The slight difference in mortality between mallards afflicted with body wounds and the controls indicates that the bulk of these birds were not fatally affected by the shot wounds.

Band returns from groups of wild mallards with and without body

TABLE 9.—THE PERCENTAGE OF BAND RETURNS FROM LIVE-TRAPPED MALLARDS SEPARATED INTO TWO GROUPS: THOSE WITHOUT BODY SHOT AND THOSE WITH BODY SHOT, 1949 AND 1950.

Group	Year banded	Number banded	Recoveries in years following banding (Sept. 1-Aug. 81) 0-1	1-2	2-3	8-4	Total Number	Per Cent recovered
No Shot	1949	760	32	51	30	8	121	15.9
	1950	506	27	33	15	..	75	14.8
	Total	1,266	59	84	45	8	196	
	Per Cent Recovered		4.7	6.6	3.5	1.0		15.4
Body Shot	1949	297	7	21	11	3	42	14.1
	1950	275	11	20	6	..	37	13.4
	Total	572	18	41	17	8	79	
	Per Cent Recovered		3.1	7.2	3.0	1.0		13.8

shot at the time of banding were also revealing of the effect of body shot on subsequent survival (Table 9). In both 1949 and 1950, current season returns were proportionately lower for ducks with body shot than for those without shot wounds. However, in subsequent years, the return of bands tended to be similar for both groups. The end result over a period of several years was that a slightly greater proportion of returns was received from the group without body shot, primarily because of the larger proportion of band returns received from this group the first year.

The lower proportion of band returns from body-shot ducks during the same hunting season as banded indicated a greater wariness to the gun on the part of those ducks which had been previously hit by shot pellets. If this lower proportion of returns was the result of an increase in mortality in the wild, then the returns from this group in subsequent years should also be lower. Consequently, survival was as high among mallards previously shot but not fatally injured as it was for mallards which up to the time of banding had not been hit.

A review of the effect of body shot as found in flying mallards indicates that the wounds produced by these shot are not serious. The comparative weights, survival of penned birds, and band recoveries indicate that a large proportion of the ducks hit but not downed will survive. The loss in ducks which are incapacitated by shot wounds but which the hunter does not observe to drop, still needs to be determined.

THE NATURE OF WOUNDS IN CRIPPLED DUCKS

Incapacitated ducks have been collected after the waterfowl season and into mid-winter in an effort to determine the cause of their affliction by fluoroscopy and, in some cases, autopsy. The bulk of the

TABLE 10.—CLASSIFICATION OF SHOT PELLETS FOUND LODGED IN VARIOUS PARTS OF THE BODY IN MALLARDS PICKED UP CRIPPLED NEAR HAVANA, ILLINOIS, 1939-1952.

Part of Body	External Shot Number	External Shot Per cent	Internal Shot Number	Internal Shot Per cent	Total Number	Total Per cent
Bill	2	0.6	0	0.0	2	0.6
Head	8	2.3	1	0.3	9	2.6
Neck	20	5.8	0	0.0	20	5.8
Chest	19	5.5	8	2.3	27	7.8
Breast	21	6.1	9	2.6	30	8.6
Belly	12	3.4	32	9.2	44	12.7
Side	30	8.6	6	1.7	36	10.4
Flank	18	5.2	7	2.0	25	7.2
Thoracic Back	14	4.0	8	2.3	22	6.3
Caudal Back	28	8.1	7	2.0	35	10.1
Wing	26	7.5	37	10.7	63	18.1
Leg and Foot	34	9.8	0	0.0	34	9.8
TOTALS	232	66.9	115	33.1	347	100.0

ducks collected for examination have been mallards, a small number of black ducks, and a very few individuals of other species. Most of those examined proved to have been incapacitated as a result of lead poisoning, but 108 individuals appeared unable to fly solely as a result of shot wounds. Of this number, 58 were incapacitated by one or more fractured wing bones; the others carried head and trunk wounds. Among 60 ducks found dead during the winter months in Michigan by Whitlock and Miller (1947), 27 had detectable shot wounds, and 13 of these had wing fractures.

A classification of shot wounds, as indicated by lead shot in various parts of the body of crippled ducks, is given in Table 10. The principal difference between shot wounds in live-trapped mallards and those picked up crippled was the greater proportion of internal shot in the crippled group.

The frequency of shot wounds among those mallards picked up in a crippled condition is shown in Table 11. In comparison with the frequency of shot wounds in live-trapped mallards (Table 6) it is evident that individuals with several shot wounds are of more frequent oc-

TABLE 11.—THE FREQUENCY OF BODY SHOT IN 108 DUCKS FOUND CRIPPLED FROM GUN SHOT WOUNDS NEAR HAVANA, ILLINOIS, 1939-1952.

Number of shot wounds	Number of ducks	Per cent of ducks	Cumulative per cent
1	40	37.0	37.0
2	17	15.7	52.7
3	19	17.6	70.3
4	9	8.3	78.8
5	10	9.3	87.9
6	4	3.7	91.6
7	3	2.8	94.4
8	3	2.8	97.2
9	1	0.9	98.1
10	2	1.9	100.0
TOTAL	108	100.0	100.0

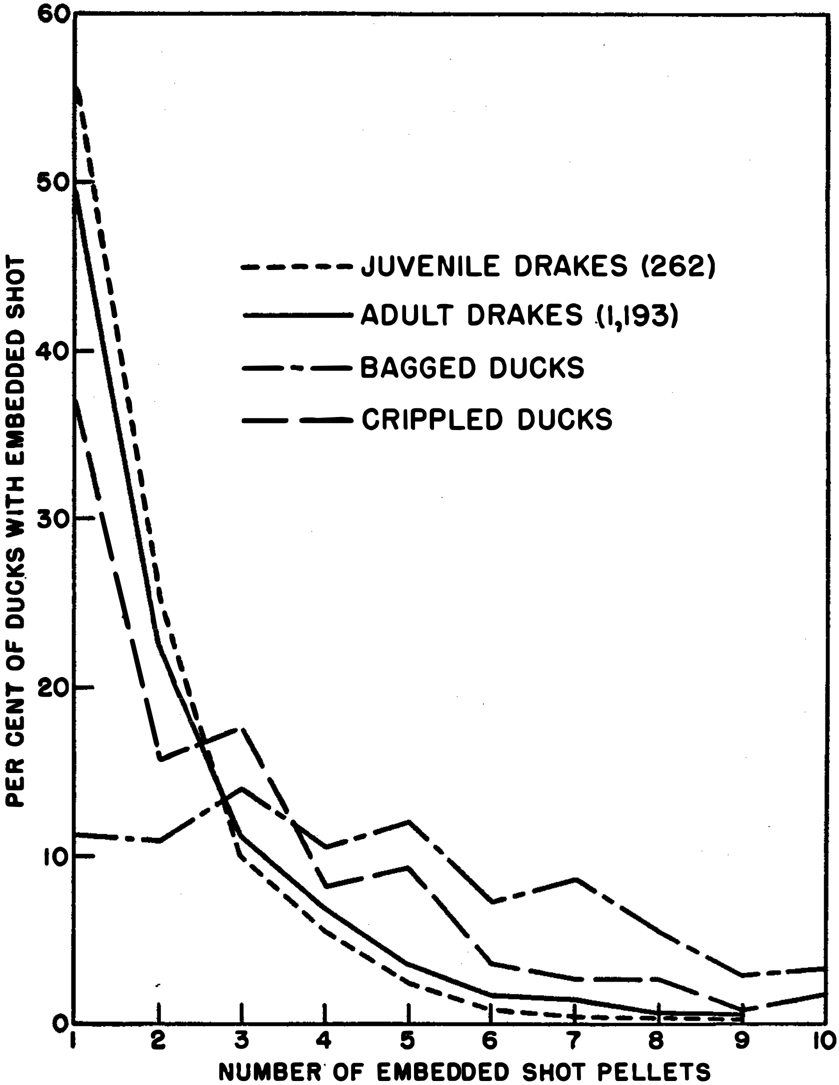

Fig. 2. The incidence of body shot in mallards live-trapped in Illinois, collected in a crippled condition, and bagged by hunters.

currence in the crippled duck group. For live-trapped juvenile drakes, only 20 per cent were found to have more than two shot wounds whereas in the crippled group 47 per cent had more than two shot wounds.

The weight at which crippled mallards died from their wounds as

TABLE 12.—THE AVERAGE WEIGHT OF DEAD WILD MALLARDS BY CAUSE OF DEATH AND SEX.

Cause of Death	Sex	Number	Average Weight
Head and trunk wounds	Drake	16	2.4
	Hen	15	2.1
Fractured wing	Drake	22	2.0
	Hen	5	1.9
Lead poisoning	Drake	78	1.7
	Hen	41	1.5

compared to the weight at which mallards suffering from lead poisoning succumbed is of interest (Table 12). Individuals in which death was attributed solely to trunk wounds died at weights higher than those with fractured wings, and those in which lead poisoning was the mortality factor died at still lower weights. This indicated that while the low weight in lead-poisoned ducks resulted largely from lead-induced starvation (Jordan and Bellrose, 1951), most ducks suffering from shot wounds died short of the starvation level.

WOUNDS IN BAGGED DUCKS

In order to discover the nature of the wounds that resulted in bringing a duck to a hunter's bag, mallards and a few black ducks killed by hunters were fluoroscoped and visually examined for shot wounds. About 60 per cent of the ducks checked had been killed by Number 6 shot, 30 per cent by Number 4 shot, and 10 per cent by shot of other sizes.

About 6 per cent of the bagged ducks fluoroscoped showed no shot pellets embedded in their body. Further examination of these birds usually disclosed that they had been bagged by a single shot pellet which passed through either the head, the neck, or fractured a wing bone. In some cases undoubtedly more than one shot pellet was responsible for a fractured wing bone, but it was assumed that only one shot was responsible.

TABLE 13.—THE FREQUENCY OF SHOT WOUNDS IN MALLARDS AND BLACK DUCKS BAGGED BY HUNTERS IN ILLINOIS AND ARKANSAS, 1950-1952.

Number of shot	Number of ducks	Per cent of ducks	Cumulative per cent
1	79	11.3	11.3
2	77	11.0	22.3
3	99	14.1	36.4
4	74	10.6	47.0
5	85	12.1	59.1
6	51	7.3	66.4
7	61	8.7	75.1
8	39	5.6	80.7
9	21	3.0	83.7
10	24	3.4	87.1
11	19	2.7	89.8
12	14	2.0	91.8
13 and over	57	8.2	100.0
TOTALS	700	100.0	100.0

TABLE 14.—CLASSIFICATION OF SHOT WOUNDS IN VARIOUS PARTS OF THE BODY OF 700 MALLARDS BAGGED BY HUNTERS, 1950-1952.

	External shot		Internal shot		Total	
Part of Body	Number	Per cent	Number	Per cent	Number	Per cent
Bill	11	0.5	0	....	11	0.4
Head	43	1.7	50	2.0	93	3.7
Neck	159	6.4	13	0.5	172	6.9
Chest	131	5.3	57	2.3	188	7.6
Breast	70	2.8	59	2.4	129	5.2
Belly	59	2.4	121	4.9	180	7.3
Side	191	7.7	18	0.7	209	8.4
Flank	137	5.5	18	0.7	155	6.3
Thoracic back	273	11.0	187	7.5	460	18.6
Caudal back	183	7.4	77	3.1	260	10.5
Wing	71	2.9	373	15.0	444	17.9
Leg and foot	172	7.0	7	0.3	179	7.2
TOTALS	1,500	60.6	980	39.4	2,480	100.0

The frequency of shot wounds in 700 mallards and black ducks brought to bag is shown in Table 13 and Figure 2. From the even distribution of shot wounds it is evident that chance plays an important role in determining whether a few shot will bag a duck, cripple it, or leave it without serious injury. In about 11 per cent of the ducks killed only one shot was responsible for bringing the duck to bag; the majority of these cases resulted from a deep wound to the brain, the severing of the trachea, or the fracturing of a wing bone. A larger number of shot, however, was required to bag most ducks; about 78 per cent of those bagged had more than two shot wounds. There was an average of 5.9 shot wounds per bagged duck compared to 2.8 shot wounds in ducks found crippled, and 1.8 shot wounds in live-trapped ducks afflicted with wounds.

A classification of shot wounds in various parts of the body of bagged mallards revealed (Table 14) that internal shot wounds occurred more frequently in bagged ducks than in crippled ducks. This

TABLE 15.—THE PROPORTION OF FRACTURED WINGS TALLIED IN SEVERAL SPECIES OF DUCKS BAGGED BY HUNTERS IN VARIOUS LOCALITIES, 1951 AND 1952.[1]

Species	Location	Number checked	Per cent with fractured wings
Mallard	Illinois Valley	1,661	71.5
	Arkansas	1,020	72.5
Pintail	Illinois Valley	201	58.7
Blue-winged teal	Wisconsin	220	49.1
	Minnesota	23	43.4
Lesser scaup	Mississippi River	52	65.4
	Wisconsin	23	56.5
Redhead	Minnesota	40	60.0
Canvasback	Mississippi River	43	72.1
	Wisconsin	32	78.1

[1]Data contributed by the following cooperators:
Arkansas: Arthur S. Hawkins and Laurence Jahn
Minnesota: Arthur S. Hawkins
Mississippi River: George Arthur and Harry Canfield
Wisconsin: Laurence Jahn and Alan Rusch

was most pronounced in the head and in the region of the thoracic back, an area occupied largely by the lungs. There were relatively fewer shot wounds internally in the belly region of bagged ducks than among those crippled, an indication that belly-shot ducks may tend to be the ones that drop at a distance from the hunter. There was an increase in the proportion of shot producing fractured wing bones in bagged ducks, an indication that such wounds were relatively more important in bagging ducks than in crippling them.

The importance of fractured wing bones in bringing various species of ducks to bag is shown in Table 15. We believe that the relative proportion of fractured wing bones found among the species of bagged dabbling ducks and of bagged diving ducks is an index to the relative shocking power required to bring the various species, within each sub-family of ducks, to bag. Thus, among the dabbling ducks, it is evident that the smaller the body, the greater the proportion of ducks brought to bag solely by shot wounds in the head and trunk. Blue-winged teals hit only in the head or trunk were less likely to fly away than were pintails, and pintails were less likely to fly away with shot in their head or trunk than were mallards.

Among diving ducks, a group notoriously difficult to kill by shot, the same relationship appears evident. Although the samples were too small to attach complete confidence, it appears that lesser scaups were more readily bagged by shot in the head and trunk than were redheads, and they, in turn, were more readily bagged than canvasbacks (Table 15).

The relationship of the target area provided by the ventral surface of the trunk compared to the area of the bones in both wings provides evidence that wing area was not responsible for more fractured wing bones in the large ducks than in the small ones (Table 16). For example, inasmuch as the target area of the wing to the trunk was comparatively proportionate for the mallard and the blue-winged teal, those teal hit by shot should have a similar proportion of fractured wings to those as mallards hit by shot. The difference found in the proportion of fractured wing bones in the two species in hunters' bags is therefore attributed to head or trunk wounds that, while bringing

TABLE 16.—THE RELATIONSHIP OF THE VENTRAL SURFACE AREA OF THE TRUNK (CHEST TO TAIL) TO THE AREA IN THE BONES OF BOTH WINGS IN SQUARE INCHES.

Species	No. measured	Area of trunk	Area of bones in both wings	Ratio of wings to trunk
Mallard	5	25.3	7.3	1:3.5
Pintail	3	18.6	6.9	1:2.7
Blue-winged teal	1	7.8	2.2	1:3.6
Lesser scaup	1	15.5	3.5	1:4.4

a teal down, would frequently fail to bring a mallard down. A fractured wing, however, brings a mallard to bag as readily as it does a blue-winged teal.

A tally of fractured wing bones in 1,400 bagged mallards revealed that about 54 per cent of the fractured bones were humeri, 25 per cent were bones of the radius or ulna, and 21 per cent were carpals or metacarpals. This is not quite proportionate to bone area, for, in wings measured, the surface area of the humerus was 1.36 square inches; the radius and ulna, 1.20 square inches; the carpals and metacarpals 1.06 square inches.

SHOOTING EXPERIMENT

The importance of range and shot size in the bagging and crippling of ducks proved difficult to evaluate under field conditions. In order to determine their relative importance a series of controlled shooting experiments were conducted in 1950 and 1951.

Game-farm mallards were used in the tests. The birds were similar in appearance to wild mallards, but they were about three-tenths of a pound heavier. All ducks were capable of flight.

Each duck was suspended in front of a sheet of paper used to record the pattern of the shot. To simulate a bird in flight the duck was posed with wings outstretched at an angle of 45 degrees to the line of fire. This position was thought similar to that of an overhead bird approaching or leaving the decoys. By facing the duck either toward or away from the shooter, targets provided by approaching or departing ducks were obtained.

A 12-gauge, full choke shotgun was used, which, in laboratory tests at 40 yards placed 72 per cent of Number 4 shot and 68 per cent of Number 6 shot in a 30-inch circle. The shells were production loads containing one and one-quarter ounce of shot. All rounds were fired from a bench-type rest to insure accuracy. The pattern of the shot on the paper behind the duck made it possible to check the alignment of the gun.

In the experiment, each shot duck was classed as bagged or crippled, depending on whether it could be retrieved or lost under field conditions. All ducks with broken wings were classed as bagged. The ducks were picked of feathers and examined visually for shot wounds. They were then fluoroscoped to determine the number and location of shot pellets embedded in their tissues.

The average number of shot pellets striking a duck at various ranges was slightly less than the computed number of pellets which would hit a target of comparable size. Perhaps the plumage caused a slight percentage of the peripheral pellets to glance aside. Visual inspection revealed that about 25 per cent of the shot pellets striking the ducks at all ranges passed through their bodies. In calculations involving the total number of shot wounds, adjustments have been made for the shot pellets passing through the trunk.

Two methods were used to assess the effect of range and shot size in bagging and crippling ducks: (1) Direct observation, and (2) the number of shot wounds as determined by visual inspection and fluoroscopy.

The number of game-farm mallards shot at various ranges and the gross results, as judged from field inspection, are shown in Table 17. At 35 yards there was no obvious difference in the effectiveness of Number 4 and Number 6 shot, but, as the range increased, the disparity between the two shot sizes widened, with Number 4's becoming the more effective shot. With ducks centered in the pattern by Number 4 shot, crippling did not appear to be an important factor until the range exceeded 50 yards; with Number 6 shot, crippling appeared to become an important consideration at ranges beyond 40 yards.

Inasmuch as fractured wings were found to be an important factor in bringing mallards to bag in the wild, an evaluation of the relationship of broken wings to range was considered important. In 1951, 62 per cent of the ducks shot at 35 yards suffered fractured wings, 62 per cent at 40 yards, 53 per cent at 50 yards, and 23 per cent at 60 yards. Because of borderline cases encountered in classifying bagged and crippled ducks in the field, the gross findings reported on above need further amplification.

As derived from the study of shot wounds in mallards bagged in the wild (Table 13), it is evident that the median, in frequency of wound number, fell in ducks with between four and five shot wounds. In the controlled shooting experiment (Table 18), the median in shot wounds from Number 4's and Number 6's combined, fell for ducks shot at 35 yards at six pellets; at 40 yards the median was between five and six pellets; at 50 yards the median was three pellets; and 60 yards, the median was between one and two pellets. This suggested

TABLE 17.—APPRAISAL OF SHOOTING GAME-FARM MALLARDS IN A STATIONARY POSITION AT VARIOUS RANGES WITH NO. 4 AND NO. 6 SHOT IN A 12-GAUGE FULL CHOKE SHOTGUN, 1950 AND 1951.

Range in yards	No. 4 shot			No. 6 shot		
	Size of Sample	Per Cent		Size of Sample	Per Cent	
		Bagged	Crippled		Bagged	Crippled
35	10	100	0	10	100	0
40	20	100	0	20	90	10
50	24	88	12	28	79	21
60	20	70	30	18	22	78
Total	74			76		
Average		89.5	10.5		72.8	27.2

TABLE 18.—THE FREQUENCY OF SHOT WOUNDS FROM THE FLUOROSCOPY OF GAME-FARM MALLARDS SHOT WITH NO. 4 AND NO. 6 SHOT AT VARIOUS RANGES, 1950 and 1951.

	Ranges											
	35 yds.			40 yds.			50 yds.			60 yds.		
Number of Shot	Number of Ducks	Per Cent of Ducks	Cumulative Per Cent	Number of Ducks	Per Cent of Ducks	Cumulative Per Cent	Number of Ducks	Per Cent of Ducks	Cumulative Per Cent	Number of Ducks	Per Cent of Ducks	Cumulative Per Cent
1	3	13.6	13.6	1	2.1	2.1	16	25.0	25.0	13	35.2	35.2
2	4	18.4	32.0	5	10.4	12.5	8	12.5	37.5	10	27.0	62.2
3	0	0.0	32.0	8	16.7	29.2	9	14.1	51.6	7	18.9	81.1
4	2	9.1	41.1	4	8.3	37.6	7	10.9	62.5	3	8.1	89.2
5	1	4.5	45.6	4	8.3	46.0	5	7.8	70.3	1	2.7	91.9
6	1	4.5	50.1	4	8.3	54.4	3	4.7	75.0	2	5.4	97.3
7	0	0.0	50.1	4	8.3	62.8	6	9.4	84.4	1	2.7	100.0
8	2	9.1	59.2	3	6.3	69.0	4	6.2	90.6			
9	1	4.5	63.5	3	6.3	75.2	3	4.7	95.3			
10	0	0.0	63.5	0	0.0	75.2	2	3.1	98.4			
11	2	9.1	72.8	2	4.1	79.3	0	0.0	98.4			
12	3	13.6	86.4	2	4.1	83.4	0	0.0	98.4			
13 and over	3	13.6	100.0	8	16.8	100.0	1	1.6	100.0			

that a duck fully centered in the shot pattern can be bagged consistently up to a range of between 40 and 50 yards.

Figure 3 shows the cumulative per cent of shot pellets in ducks shot experimentally with Number 4's and Number 6's at ranges of 40, 50, and 60 yards as compared to the shot wounds in mallards bagged in the wild and found crippled. The line denoting mallards bagged in

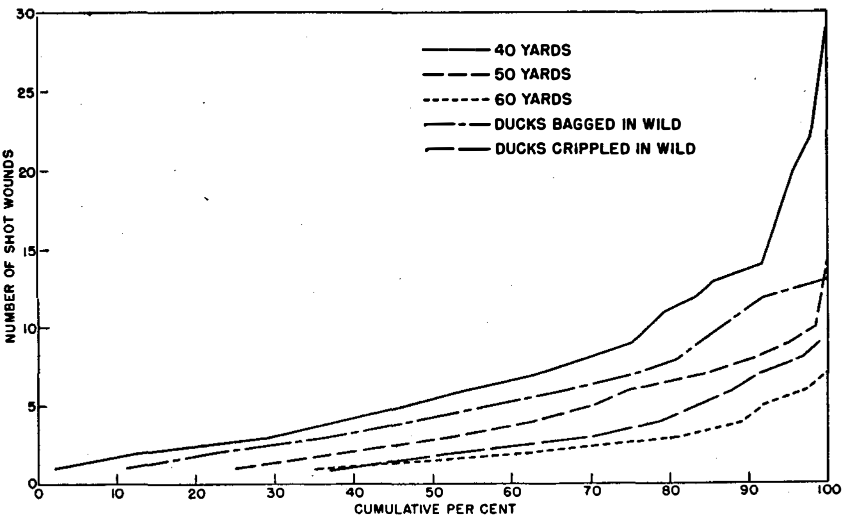

Fig. 3. The effect of range on the number of shot wounds in game-farm mallards compared to the number of wounds found in ducks bagged and crippled in the wild.

TABLE 19.—THE AVERAGE NUMBER OF 4'S AND 6'S HITTING THE TRUNK OF GAME-FARM MALLARDS AND PENETRATING INTO THE BODY CAVITY AT VARIOUS RANGES, 1950 AND 1951.[1]

Range in Yards	Number 4 Shot			Number 6 Shot		
	Ave. No. of Shot		Per Cent Penetrate	Ave. No. of Shot		Per Cent Penetrate
	Hit	Penetrate		Hit	Penetrate	
35	6.6	4.3	65	11.6	5.4	47
40	5.7	3.9	68	8.8	3.6	41
50	3.2	1.9	59	5.2	1.7	33
60	2.5	1.2	48	3.4	0.6	18

[1]Includes shot that passed through the body.

the wild falls about mid-way between the lines marking the frequency of wounds placed in game-farm mallards at 40 and 50 yards; the line denoting frequency of wounds in mallards found crippled in the wild falls between lines marking the frequency of wounds placed in game-farm mallards at 50 and 60 yards.

The average number of Number 4 and Number 6 shot pellets which struck the trunk and penetrated into the body cavity of game-farm mallards at various ranges is shown in Table 19. Not only did the number of shot pellets which hit the trunk decrease with increased range, but the proportion of shot which penetrated into the body cavity also decreased. It should be noted that at 35 yards a higher proportion of Number 6's penetrated into the body cavity than did Number 4's, but, at longer ranges, comparatively greater proportions of Number 4's penetrated into the body cavity. Although at all ranges more Number 6's struck the trunk of the ducks than did Number 4's, the effect of the greater striking force per pellet of the Number 4's necessitates further analyses.

The comparative striking force of the shot pellets hitting game-farm mallards was measured by the average number of pellets hitting the trunk times the foot pounds of energy at the point of impact (Table 20). At 35 yards, the striking force of Number 4's and Number 6's was similar. At longer ranges, however, the striking force of Number 4's was greater than that for Number 6's.

Perhaps a better method of evaluating the relative effect of Num-

TABLE 20.—THE AVERAGE NUMBER OF 4'S AND 6'S HITTING THE TRUNK OF GAME-FARM MALLARDS AT VARIOUS RANGES WITH THE "SHOCKING POWER" EXPRESSED IN FOOT POUNDS OF ENERGY.

Range in Yards	Number 4 Shot			Number 6 Shot		
	Ave. No. Shot	Ft. Lbs. of Energy		Ave. No. Shot	Ft. Lbs. of Energy	
		Per Pellet	Total		Per Pellet	Total
35	6.6	5.0	33.0	11.6	2.5	29.0
40	5.7	4.5	25.6	8.8	2.4	21.1
50	3.2	3.6	11.5	5.2	1.9	9.9
60	2.5	3.0	7.5	3.4	1.5	5.1

TABLE 21.—THE AVERAGE NUMBER OF 4'S AND 6'S PENETRATING INTO THE BODY CAVITY OF GAME-FARM MALLARDS AT VARIOUS RANGES WITH THE COMPARATIVE SHOCKING POWER DETERMINED ON THE BASIS OF NUMBER OF TIMES PELLET WEIGHT.

Range in Yards	Number 4 Shot Av. No. Internal Shot	Number 4 Shot Pellet Wt. (grains)	Number 4 Shot Internal Impact Product	Number 6 Shot Av. No. Internal Shot	Number 6 Shot Pellet Wt. (grains)	Number 6 Shot Internal Impact Product
35	4.3	3.20	13.8	5.4	1.78	9.6
40	3.9	3.20	12.5	3.6	1.78	6.4
50	1.9	3.20	6.1	1.7	1.78	3.0
60	1.2	3.20	3.8	0.6	1.78	1.1

ber 4's and Number 6's on the game-farm mallards at various ranges is the internal impact product (Table 21); this was obtained by multiplying the number of pellets in the body cavity by the weight per pellet. The result shows a higher internal impact product for Number 6's at 35 yards, but a higher internal impact product for Number 4's at 40, 50 and 60 yards.

CONCLUSIONS

Shot striking a duck results in one of three things: (1) It brings the duck to bag; (2) the bird falls, but escapes as a cripple; (3) the duck is wounded but continues in flight apparently unharmed.

Ducks are well constructed to survive shooting. Their viscera are shielded by a relatively large sternum, heavy pectoral muscles, and a large pelvic girdle. The body cavity covers an area less than half as large as the entire trunk area. In order to bring a duck down, shot must penetrate the brain, break the vertebral column, sever the trachea, fracture a wing bone, or penetrate the body wall with an impact sufficient to damage seriously vital organs.

The fracturing of a wing bone was the most important single type of wound resulting in the bagging of ducks. The larger the duck, the more important the fracturing of wing bones became in bringing ducks to bag.

Of the ducks which were knocked down by hunters, as reported from various sections of the United States, 22.5 per cent were not retrieved. An additional but unknown proportion of ducks were probably crippled but were not observed to fall or were not reported.

Information on the survival of crippled ducks is meager, but that which is available suggests that it is slight. About half of the crippled ducks collected in the wild have had fractured wings, yet very few wings with healed fractures have been found in flying ducks. The proportion of cripples with head and trunk wounds which are likely to recover is even more speculative, but judging from their heavy weight at death, they do not live as long after being shot as ducks with fractured wings. The small proportion of flying mallards with internal shot wounds also indicates that only a small proportion of the ducks with such wounds survive.

For every 100 live-trapped mallards which were fluoroscoped during the hunting season, 27 were found to have body wounds. Because many adults carried body shot from previous hunting seasons, the per cent of juveniles with body shot provided the best indication of the proportion of the flying population hit in any one year. During the hunting season in Illinois, 18 juvenile drakes out of every 100 fluoroscoped were found to have shot wounds.

The flying ducks found with body wounds represent those which were hit but continued essentially unharmed and those which were more seriously wounded but subsequently recovered. An evaluation of the effect of these wounds on survival, indicates that the ducks so affected live as long as other ducks.

Applying these findings to a waterfowl population which has not yet been subjected to shooting, it may be predicted that about 60 out of every 100 mallards flying south along the Mississippi Flyway will be hit by shot. Of this number, 32 will be bagged (Bellrose and

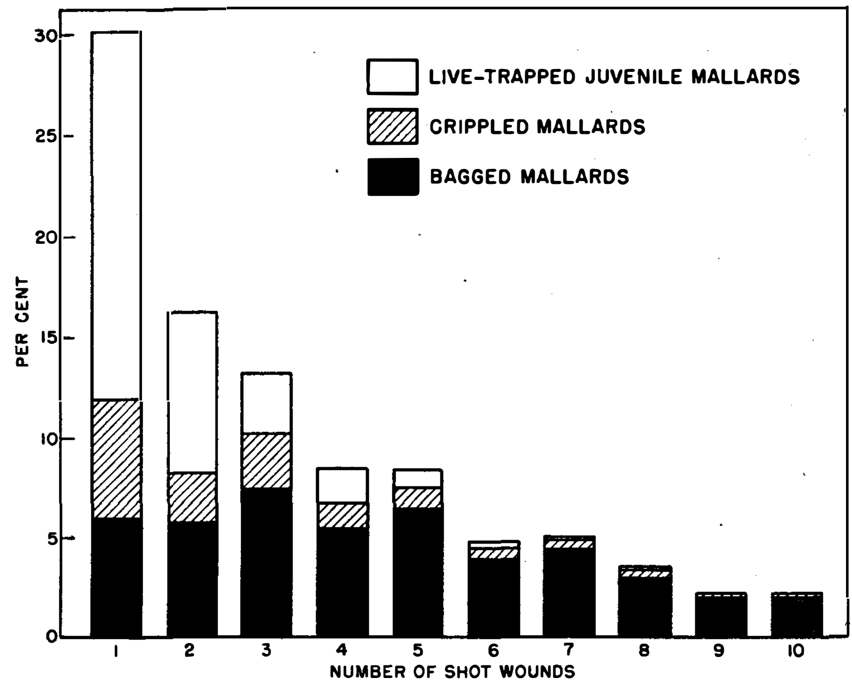

Fig. 4. The fate of mallards hit by various numbers of shot during the hunting season.

Chase, 1950); 10 will escape in a crippled condition and, of these, only one or two will recover; 18 will be hit by shot pellets but will suffer no apparent ill effects.

The effect of shot striking mallards in the wild is shown in Figure 4. Thirty per cent of the mallards hit by shot of all sizes were hit by only one pellet, which brought about 6 per cent to bag, crippled 5.8 per cent, and 18 per cent flew away with shot in their tissues. Two pellets struck about 16 per cent of those hit, bagging 5.8 per cent, crippling 2.5 per cent, and failing to seriously injure 7.9 per cent.

A great reduction in the proportion of cripples occurred in mallards struck by four or more shot. Whereas almost twice as many mallards were bagged with four or more wounds as with less than that number, over twice as many cripples occurred in birds with three wounds or less.

It is quite evident that the effectiveness of shot drops rapidly as the range increases. Not only were target ducks hit by fewer shot as the range lengthened, but the pellets had less power.

Based upon observation of results of the experiments in the field and upon an analysis of shot wounds in the laboratory, mallards fully centered in a shot pattern cannot be consistently bagged at ranges exceeding 50 yards for Number 4 shot and 40 yards for Number 6 shot. Beyond these ranges, crippling becomes an ever increasing probability for the respective shot sizes.

Because of the necessity of hitting mallards with at least four pellets to minimize the crippling potential, a full choke gun is of prime importance at ranges of 40 yards or more. In addition to hitting a duck with a sufficient number of pellets, the pellets must have sufficient energy to penetrate the skull, the body wall, or break a wing bone. If crippling losses are to be reduced, hunters must not only restrict their range according to the shot size used, but must learn how to swing on a moving target and estimate lead.

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INDUSTRIAL POLLUTION AND MICHIGAN WATERFOWL[1]

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INTRODUCTION

For a number of years there has been increasing concern among Michigan sportsmen and conservationists for the welfare of waterfowl that winter on the Detroit River and that part of Lake Erie adjacent to the river mouth. This concern reached a peak in the early months of 1948 (Miller and Whitlock, 1948) when an estimated 10,000 ducks perished, most of them canvasbacks, scaups, redheads, and black ducks. The loss of the birds was variously attributed to a combination of cold weather, lack of food, and industrial pollution. As might be expected there were demands for an intensive investigation.

No one was prepared to say to what extent the loss could be attributed to cold weather, or to starvation, or to oils or other pollutants common in the waters of the Detroit River. It was this doubt as to the role played by the various factors that pointed up the need for more information concerning these wintering waterfowl.

A waterfowl research project under the Pittman-Robertson Federal Aid Program had operated in this area during the early 1940's. A part of this project was a trapping and banding program. It was logical and relatively simple to expand the project that had previously

[1]A contribution from Federal Aid in Wildlife Restoration Project 45-R, Michigan.

existed to include a study of the factors believed responsible for winter mortality. This expanded program was initiated in 1949.

The Detroit River, the thirty-mile connection between Lake St. Clair and Lake Erie, carries the outflow of Lakes Superior, Michigan, and Huron. Prior to the mid-1930's a waterfowl problem did not exist since the shallow, food-rich lower half of the river froze from bank to bank and the narrow, deep, but ice-free upper half supported little food as an encouragement for ducks to remain during the winter. Then, industrial plants, attracted by what appeared to be an unlimited supply of water, developed rapidly along the lower west bank of the river. Effluent warmed the waters to the extent that parts of the lower river were always ice-free. Migrant waterfowl lingered, and for a number of years upward of 50,000 have remained each winter. An unfortunate result of the industrial concentration has been the increasing pollution of the river.

A principal objective of the present waterfowl study has been the attempt to evaluate the factors causing the losses suffered by wintering ducks. The answers to a number of questions were needed. How much waterfowl food was present in the river? Was ample food available throughout the winter? How many ducks wintered in the area? What types of industrial wastes affect waterfowl? Were there factors other than food, weather, and pollution involved?

In order to obtain answers various surveys and investigations were pursued. Trapping and banding was continued to gain information concerning the weights, movements, species, sex, and ages of wintering ducks. During the years 1949 through 1952 nearly 30,000 ducks have been live-trapped, banded, and examined. Black ducks, canvasbacks, lesser scaups, and redheads made up the bulk of the species handled.

About 7,700 of the ducks captured were fluoroscoped to determine the presence of lead shot in the gizzard in order to obtain an indication of the importance of lead poisoning as a factor in the situation. In addition the presence of shot in the body tissues was recorded to secure information about the influence gunshot wounds might have on the total picture.

Periodic aerial censuses have enabled us to secure data concerning migration periods, numbers of waterfowl present in given areas, species composition, ice conditions, and estimates of mortality. More frequent observations were made from the ground of the waters surrounding Grosse Ile to secure data similar to those obtained from the aerial surveys.

A map of aquatic food plants was prepared for that part of the river around Grosse Ile. The food beds were rated to indicate their value for ducks.

Many hundreds of the waterfowl from the study area have been autopsied to determine the causes of death. Bacteriological examinations,[2] chemical analyses for toxic substances, and other techniques supplemented the normal type of post-mortem examination.

A survey was made of industry on the Detroit River and the wastes emitted by various industries under suspicion. Personal observations, review of records, and consultation with plant managers were employed to secure this information.

The effects of some industrial wastes on waterfowl were evaluated by experiments. Thus, we have not only data gathered from live ducks by trapping and autopsy information but experimental facts as well.

Records of local weather conditions have been kept throughout each winter trapping season. This information has proved valuable in analyzing periods of mortality.

FINDINGS

Of the 7,700 ducks fluoroscoped, less than 4 per cent showed the presence of lead shot in the gizzard. Comparison of average weights by species, sex, and age groupings of live ducks with and without gizzard shot shows there is no essential difference in weights. There was no significantly greater incidence of gizzard shot in ducks found dead than in living ones. From the summarized data it is evident that lead poisoning is a minor factor causing mortality among waterfowl on the Detroit River.

Slightly more than 13 per cent of the ducks fluoroscoped contained lead shot in the body tissues. A comparison of average weights indicates there is essentially no difference between those waterfowl carrying body shot and those free of it. Ducks found dead during the winter showed no greater incidence of lead shot in body tissues than did live ducks. That many hundreds of ducks which contained body shot were flying and in good weight weeks and months after the hunting seasons, indicates that they were not an important factor in winter mortality.

Cold weather in itself is apparently not a cause of death. To support this statement one needs only to consider the flocks of waterfowl wintering at Alpena, Michigan (200 miles north of the study area) where there is ample food available, open water, no pollution, no mortality, and temperatures much lower than those encountered on the Detroit River. In several marshes at the west end of Lake Erie near

[2]These examinations were carried out by the Conservation Laboratory and the Michigan Department of Health Laboratories at Lansing, Michigan, and the Detroit Testing Laboratory, Detroit, Michigan.

the Detroit River, there are sulphur water springs where small numbers of ducks spend the winter on open water and suffer no mortality.

However, severe cold coupled with ice coverage of major food beds is of great importance. We have found that weights of diving ducks (these make up the bulk of the waterfowl wintering on the Detroit River) fluctuate with changes in ice coverage of the food beds. When major parts of beds of aquatic plants are covered by ice for two weeks or more, weight losses and mortality occur among the ducks. As ice cover is reduced by moderating temperatures, duck weights increase. For example, lower than average weights occurred coincident with low temperatures and much ice during December, 1950, and February, 1951. Average weights were greater during January, 1951, when temperatures were mild and there was less ice. A period of mortality occurred during the cold weather of February, 1951, and the bulk of the carcasses recovered were so emaciated that average weights were 30 per cent less than those of healthy ducks. Clearly, starvation was a major factor here, although 25 per cent of the dead ducks had oil on them.

An experiment designed to secure information about lack of food was conducted. Several species of normal-weight, healthy diving ducks were confined in such a way that all life requirements were available except food. All the experimental ducks died within nine days. Autopsy revealed no other factors than starvation caused death. The thousands of free-flying "controls" on the Detroit River during the time of the experiment suffered no mortality and lost little weight. There was little ice on the Detroit River at the time. Examination of the experimental ducks revealed a "picture" similar to that secured from the autopsy of many hundreds of the ducks found dead at various times on the river, namely: A weight about two-thirds that of normal, few or no parasites, no lead poisoning.

From the beginning of this study it was apparent that the dangers to waterfowl lay in chemical rather than bacterial pollution. (The latter is usually emphasized in pollution investigations because of the greater menace to the human population.) The main sources of chemical pollution are industrial wastes. A survey was initiated to determine the types of industrial wastes entering the Detroit River and the sources of these wastes. We would like to note here that considerable assistance was given in the survey by field representatives of the Michigan Water Resources Commission. Also, much of the information we gathered was confirmed or augmented by the Report of the International Joint Commission on the Pollution of Boundary Waters and conversations with men who did some of the field work for the I.J.C. investigations (International Joint Commission, 1951).

Materials in the industrial effluent entering the Detroit River and recognized as, at least, potentially dangerous to waterfowl fall generally into one of the following categories:
(1) Those containing elements or compounds known to be toxic to wildlife, (2) suspended non-toxic solids, (3) organic materials with high bio-chemical oxygen demand (B.O.D.), (4) oils and greases.

Included in the first category are phenolic compounds, ammonium compounds, cyanides, certain acids and alkalies, and elemental yellow phosphorus. Most of these materials, with the exception of yellow phosphorus, are now believed to be of little consequence to waterfowl in the Detroit River due to the extreme dilution and the fact that most factories releasing them are considerable distances from areas where waterfowl concentrate. Yellow phosphorus, which is very toxic and only slightly water soluble, has been known to escape in the area where wintering ducks concentrate. In 1948 it (Miller and Whitlock, 1948) played a role in the mortality of that year. There is no evidence to indicate that yellow phosphorus has escaped since 1948. Actually the phosphorus is a raw material, not a waste product, and was lost only through accident. Further reference concerning the effects of yellow phosphorus on waterfowl may be found in Coburn *et al.*, 1950, and Ewing, 1951.

Suspended non-toxic solids include such materials as iron scale, and slightly soluble salts, such as calcium carbonate, and others. Hundreds of tons are released into the river annually. However, most of these are relatively inert and, since they are released in areas where there is little danger of covering aquatic food beds, are believed to be of little danger to waterfowl.

Organic materials with a high B.O.D. can be dangerous to waterfowl if released where they can accumulate and decompose in quantity. Under certain circumstances such a condition would be conducive to the growth and spread of the botulism organism. (Pirnie, 1935, for conditions favorable to botulism.) However, the flow of water in the Detroit River practically precludes the proper combination of factors contributing to vigorous growth of the organism.

Of the various wastes now recognized, oils and greases are among those most dangerous to waterfowl. The survey team of the International Joint Commission estimated that more than 16,000 gallons of oil were entering the Detroit River daily at the time they were making their study between 1946 and 1948. At least seventeen industrial plants were observed releasing oil into the Detroit River during this waterfowl study. Some of these industries release oil in relatively small amounts. However, even small amounts can be dangerous since oils, unlike water-soluble materials, tend to accumulate in eddies and backwaters and then, during periods of unusually heavy surface run-off, are flushed from these areas of accumulation and act the same as extensive flows.

The effects of oil on ducks have been studied in two ways: by field observations and by experiments. As the study progressed it became increasingly evident that no hard and fast rules could be established as to the exact amount of oil which might be labeled dangerous to waterfowl. Under some circumstances a very small amount of oil might be dangerous. Under other circumstances the same amount of oil might have no adverse effect. Oils of different viscosities appeared to have different effects on experimental birds. Mallards placed in water on which heavy fuel oil was floating remained incapable of flight from two weeks to a month after their feathers had absorbed approximately twenty milliliters of oil. During a similar experiment with Pekin ducks it was noted that much time was spent preening and little time spent feeding. Similar birds placed in a like amount of a light (No. 2) fuel oil for the same length of time suffered no apparent ill effects. On the other hand a flock of 75 ducks, mostly scaup, was almost entirely wiped out in a few hours by No. 2 fuel oil which accidentally leaked from a tank and drained into a small pond where the birds were sleeping or feeding. The accident occurred during the night and by morning most of the birds were dead.

On two occasions in the early months of 1952 ducks died during oil flows on the Detroit River after entering live-traps. On both occasions the birds had entered the traps at night. Later, an oil flow passing through the traps caught the helpless birds and by morning, when the traps were checked, most of the birds were dead. All of the dead birds were found to be in good weight. There was no evidence to indicate that any of the birds were suffering from disease or poisoning. Those still alive were found swimming for their lives with their heads barely above water. A number of dead ducks had lost all buoyancy and settled to the bottom. Chemical analysis indicated that two weights of lubricating oil, SAE 10 and SAE 40, were involved in these losses. Extraction of the lubricating oils from the feathers of some of the birds revealed that the amount of oil on the feathers varied from as little as 0.54 grams on one specimen to slightly over 4 grams on the oiliest specimen. Apparently, death resulted from becoming water-logged and drowning.

From these experiments and observations it appears that non-toxic oils affect waterfowl directly in one of four ways, all external. The insulating effect of the feathers may be impaired, causing the bird to suffer from exposure. Buoyancy may be lost, causing the bird to drown. Loss of flight may leave the bird easy prey for predators. So much time may be spent in attempting to clean oil from its feathers that the bird neglects to eat, weakens and becomes susceptible to adverse weather.

Oil which settles to the bottom may be, in time, more detrimental to waterfowl than are the immediate effects of the oil floating on the water. Bottom samples taken during the study of the food beds in the Detroit River revealed that in some areas the bottom is coated or impregnated with sludge. During dredging operations which are conducted annually in the lower three miles of the Rouge River, a tributary of the Detroit River, more than 17,000 gallons daily of oils and greases are scooped from the bottom for a period of fifty days, according to the report of the I.J.C. This sludge, along with other material, is removed to the lower Detroit River where it is dumped to be carried away by the current. Simple arithmetic shows that over 2000 gallons of oil are settling daily to the bottom of the Rouge River. Much more is probably settling to the bottom of the Detroit River, although there is no way to prove it. In examining samples of bottom soil taken from the lower Rouge River it was noted that there is virtually no plant life and little animal life. It is impossible to tell the extent to which oil is responsible for this biological desert, but it unquestionably has played a role.

What effect this sludge may have over a large area on the vegetation rooted on the bottom and drawing nutrients from the soil has not been fully investigated. One-half of a planted wild celery (*Vallisneria spiralis*) bed was treated with sludge during one of our experiments in 1951. Survival of the plants in the treated section was less than 50 per cent of that in the untreated section.

The question arises, of course, could what has happened to the Rouge River also happen to the Detroit River? The answer is, yes, conceivably. It is possible that pollution this year may be responsible for waterfowl losses five years hence. Perhaps food beds in the channel on the west side of Grosse Ile were destroyed years ago by oil pollution. Perhaps many of the ducks that died in 1950 and in 1951 would have survived if those beds had still been in existence since those feeding beds were the ones free of ice during even the coldest weather. We can only speculate; we cannot be sure.

CONCLUSIONS

Interpretation of the information leads us to conclude that three major factors are involved in causing winter mortalities on the lower Detroit River. They are: (1) cold weather, (2) starvation, and (3) pollution. There is no evidence that cold weather will directly cause mortality here, but ice cover resulting from cold weather reduces the availability of food, and starvation ensues. Pollution will directly kill ducks as shown by experimental and field data. Also, an oil-covered duck may starve due to the great amount of time spent in attemping to clean itself and little time spent in feeding. Or, it may starve because it cannot fly to a food source due to oil-coated feathers. Pollution coupled with cold weather may cause death from exposure. In many cases the three factors are so interrelated as to be inseparable.

RECOMMENDATION

Weather is not likely to be controlled within the foreseeable future; therefore, waterfowl losses from starvation due to ice covering food beds cannot be reduced. However, direct and indirect losses of waterfowl resulting from pollution here, and elsewhere on the continent, can be reduced considerably by vigorous enforcement of adequate pollution control laws.

SUMMARY

Heavy losses among waterfowl wintering on the Detroit River in 1948 required that interested parties study the matter. An earlier project was expanded to include an investigation of the cause or causes of death among the tens of thousands of ducks which winter there.

Ducks were live-trapped, banded, weighed, fluoroscoped, sexed, aged, and species determined. Censuses were made. Aquatic plant beds were mapped. Dead ducks were examined. A survey of and experiments with industrial wastes were made. Records of weather and ice conditions were kept.

Our findings are as follows:

(1) Lead poisoning or disablement from gunshot wounds account for only a small proportion of the winter losses and are considered of little importance as mortality factors.
(2) Cold weather uncomplicated by other factors does not cause ducks to die.
(3) Disease is not a factor in these winter deaths.
(4) Ice coverage of major food sources is a factor contributing to winter losses.
(5) Oils, greases, and, on one occasion, yellow phosphorus are the only pollutants, so far as we know, which have caused ducks to die.
(6) Cold weather, lack of food, and exposure to oils and greases in varying combinations have caused losses among wintering ducks.

Since weather is not likely to be controlled in the near future, and ice will cover food sources, the only reasonable recommendation at

present is that adequate pollution control laws and their vigorous enforcement are necessary. Losses among waterfowl should be materially reduced by such action.

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DISCUSSION

MR. GOODRUM: It seems as if proper legislation towards controlling pollution is 'way behind. Since the last World War many industries have been developed, plus the fact that a great many more have moved south, causing a number of problems in some states that heretofore haven't had too much trouble; for example, the paper pulp industry has moved to the South. Numerous other types of new industries are setting up nearly all kinds of industrial enterprises. This is causing a great deal of losses, not only to ducks, but to other forms of wildlife. With the decreasing number of desirable water areas for ducks, we have also an increase in industrial pollution, making the situation very bad. They are trying to do something about it with proper legislation, but some of the interests are so well financed that the legislation seems to be making very poor progress. Even after you have the proper legislation, you find that enforcement is a problem also. I wonder if anyone has any comment on this important development.

MR. REZON. (University of Massachusetts): Mr. Chairman, I wonder if the speaker could give us a little more detail on that death period, that nine days. Was it the same with all ducks, and what time of the year was it?

DR. HUNT: We used last year scaups, redheads, and canvasbacks. It was during March. The weather conditions were more or less cold. I would say that the average temperature was somewhere around freezing. Individual birds died at varying periods from four to nine days. Their weights at the time they were placed in the folding pens were normal in comparison to those we were live-trapping at that time. We live-trapped those birds and confined them almost immediately.

MR. GOODRUM: There appears to be no further comment, Mr. Chairman, but I would like to make one other remark. Some of the southern state governments are subsidizing, giving a premium, to oil companies to move into their states to explore for oil. I believe that Georgia is one of those states. I don't know the extent of it, but anyway the development of oil is being pushed in states that heretofore haven't done anything along that line. Alabama is now having some oil pollution because of oil development. They don't seem to be able to curb pollution; it seems to occur before the people and the sportsmen find out what is going on. In other words, the action taken is 'way too late to do much about it.

This occurred, for instance, in the kaolin plant. I know, for example, in Georgia I examined one stream where they had dumped the waste and for eight miles the creek resembles a creek of milk, and practically suffocating every fish in it. As far as I know, there has been nothing done about that.

It seems as if this is one problem that needs a little more attention on a national scale and more rigid enforcement by the various states.

WOODCOCK STUDIES IN MASSACHUSETTS[1]

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The American woodcock achieves its most prominent place on the roster of upland game in those states north of the ranges of the pheasant and quail where the ruffed grouse is the only other available game bird. In years of grouse scarcity, northern bird hunters depend chiefly on the woodcock for sport.

During the last four years, the Massachusetts Cooperative Wildlife Research Unit has conducted intensive studies of woodcocks on their breeding grounds in the central part of the state. Although this research has been broad in scope, particular attention has been focused on the breeding activities and movements of individual adult males. Because of the birds' vulnerability to shooting, other workers have pointed to the legislative tool of setting seasons and bag limits as the most effective method of management. As in the case of waterfowl, therefore, the accuracy of the annual inventory becomes of paramount importance. Based on the count of singing males along stretches of road in woodcock breeding habitat, many census cooperators have reported extreme variations of count during the same season. Some of the factors causing such apparent discrepancies have been brought to light by capturing and banding breeding males.

By the development of an automatic decoy trap patterned on the principle of the one developed in Pennsylvania (Buel, Studholm, and Norris, 1940), 445 captures of male woodcocks have yielded the data presented in this report. These captures include repeats in the same season and returns from other years of 325 separate birds.

Most of these studies have been made in Quabbin Reservation near Amherst, Massachusetts. This is a tract of approximately 100,000 acres surrounding a large reservoir, all of which is under the control of a metropolitan water commission. At about 1,000 feet above sea level, this terrain is hilly and, as recently as 18 years ago, was farmed. After the removal of all houses and residents, the open fields were planted with white and red pines. These plantations of varying ages with suitable surrounding habitat are favorite breeding grounds for woodcocks.

TRAPPING RESULTS

Monogamy or polygamy. Whether an animal is monogamous or polygamous is of interest to the game manager and has a direct bear-

[1]A contribution of the Massachusetts Cooperative Wildlife Research Unit supported by the U. S. Fish and Wildlife Service, University of Massashusetts, the Massachusetts Division of Fisheries and Game, and the Wildlife Management Institute.

ing on this study. Previous investigators have not agreed as to whether the woodcock takes one mate for the season or more. The Massachusetts studies strongly suggest the male woodcock is promiscuous. The evidence for such becomes apparent as one examines the behavior data.

It is not unusual to find the same singing male attempting mating with different decoys at widely separated singing sites on different nights.

Birds first captured in April have been found visiting singing grounds of other males and attempting to breed with a decoy after May 15 when presumably most males should be mated if monogamous.

There was one instance of a male observed copulating with a decoy while a live bird (presumably a female) was on the ground eight feet away. It could not be proved the other bird was a female, but the observer was within a few feet and the actions of this bird were typical of other females seen on singing grounds.

In two cases, two males were using the same singing ground the same evening and in each case one was captured, the trap reset, and the second male attempted mating with the decoy.

In several instances, broods were found in close proximity to males which readily decoyed in May.

Recaptures of males trapped in previous years. Fifty-four recaptures of males trapped in previous years revealed interesting data on homing instincts and population turnover. Forty per cent of these returns were recaptured on the same singing site where taken in former years. Sixty per cent were caught in other singing grounds located an average of slightly over one mile from the former year's capture site. There was one instance of a bird choosing a new temporary site 7 miles away and another which had moved 5 miles. One individual was caught three times, twice in 1951 and once in 1952, all at widely separated singing fields. Another was captured twice in 1951 and four times in 1952 at three separate singing grounds separated in one case by over two miles.

One of the original five birds captured in 1949 was not recaptured on his old singing site in 1950 although two other birds were taken there. In 1951 he was recaptured on his original field but was using a different location in the field.

Only one of five birds captured in 1949 was taken in four consecutive years. In 1950 he used a singing ground 600 yards from his 1949 capture site, which was being used by another bird. In 1951 and 1952 he returned to his original capture site.

Failure of males to return to the same singing sites used in previous years was not due in all cases to dispossession by other males or to the site "going by" because of a change in vegetation.

In spite of some of the instances cited above, records indicate most males return at least to the general vicinity of breeding grounds used in other years.

Although the data are admittedly meager, the estimated annual population turnover based on these returns is worth recording. Since approximately 37 per cent of banded males were retrapped both in 1951 and 1952, there is a suggested population turnover of 63 per cent. Estimates of juvenile and adult mortality are based on four assumptions: (1) there is an even sex ratio; (2) the unbanded males comprising 63 per cent of the population on the study area are juveniles of the previous year; (3) the total population is unchanged; (4) the production of juveniles is 3.88 per pair as determined in Maine (Mendall and Aldous, 1943). The calculated annual mortality of adults is 63 per cent and of juveniles 68 per cent.

Repeats. The most significant information bearing on interpretation of census runs was gained through retrapping birds the same season. Casual observation in 1950 suggested either a late spring influx of breeding males or a resurgence of breeding activity in May. Therefore, in 1951 and 1952, concentrated retrapping of sites yielding birds in April was conducted beginning in mid-May. The records of 44 captures are of interest. Seventeen were new birds, 18 were repeats trapped in the same sites where taken in April, and 9 were repeats which had changed singing grounds. In addition, there were a good many instances of repeats when several sites were being trapped at one time and traps left more than one night. It was not uncommon to catch different birds in the same site on successive nights. In 1951 and 1952, when traps were left in the same site after one bird had been captured, 45 additional males were caught. One site yielded five different males on five successive nights. Eleven males have been caught at this same site in three springs.

Trapping returns are fragmentary. Many birds present undoubtedly elude the traps. Some males are more susceptible to decoying than others. The number of trap-nights on a single site is a factor of importance.

The distance repeats will move has a direct bearing on census techniques as will be pointed out shortly. There was one instance of a bird caught on one site on a Tuesday night and in another site 3½ miles away on a Thursday night. Movements of half a mile or more, however, comprise only 20 per cent of the repeats.

In at least two instances when observers watched a trap and could reset it, two males were caught the same night on the same site.

Movements of birds from one singing ground to another continued throughout the spring, well past what is considered the height of the breeding season.

The degree of territorialism seemed to vary between birds, and there were many instances of a surprising amount of intraspecific tolerance.

Arrival dates of resident males. Although many apparently migrant woodcocks pass through the Connecticut Valley in early or mid-March, birds have never arrived on the trapping grounds in the higher hills until late March during the past four years. In these studies where it has been shown that a number of different males are often captured the same year on the same site, one poses the question as to what percentage may be migrants. The only evidence produced to answer this question is an analysis of the dates of capture of returns from previous years. Most of these returns have been caught well past the middle of April when, it can safely be assumed, nearly all the migrants have passed through. Since it is a physical impossibility to trap all former successful sites simultaneously, one must rely on returns captured before April 15.

Out of a total of 48 individual birds captured two years or more in succession, 26 were caught on at least one occasion on or before April 13. Six were caught at the end of March when trapping was started, nine were caught by April 7 and seven were captured between April 7 and April 13. No attempt to trap most of the remaining 22 birds could be made until after April 15.

The bulk of the evidence suggests that resident males of former years arrive in the trapping grounds in the first wave of migrants in the spring. The study has not as yet yielded any information on the arrival dates of young birds reared on the study area the previous year.

CENSUS STUDY

Before discussing the application of some of the trapping data to census techniques, the current inventory method should be briefly reviewed. During the height of the breeding season after migrants have passed, the census taker drives along a road through woodcock breeding habitat stopping the car every 0.2 of a mile and counting, at each stop, the singing males on each side of the road. Mendall (1943) suggests that a complete flight-song heard at least on two evenings separated by several days constitutes an occupied singing ground. The number of occupied singing grounds constitutes the index of population. Extreme weather conditions and bright moonlight nights are to be avoided. A minimum of three runs has been recommended.

The method is modified by many experienced cooperators. Probably no two cooperators use exactly the same system.

Two special studies by graduate students have been conducted under Unit supervision to discover the extent of variation in census count and the variation in the performance of one individual bird. In 1951, 17 censuses were taken along a stretch of road in Quabbin Reservation and in 1952, 28 censuses along the same route. Even if one omits the counts before April 15, when there may have been migrants passing through, and after May 10, when breeding activity might be falling off, the variation in count is large. Analyses suggested no correlation between weather conditions and count unless the former was extreme or there was bright moonlight. In 1951, the count varied from 10 to 22 and, in 1952, from eight to 17 (Figure 1). It is of interest that the highest count in both cases occurred during the first week in May. We have not yet discovered any logical explanation for this. With the exception of the first week in April, the first week in May has produced the highest counts and also has yielded the highest percentage of success in trapping. It points to a resurgence of breeding activity. The only possible correlation is that it has occurred just after the height of the hatch in Massachusetts coverts. Similar high counts in May have been recorded by Norris in Newburyport, Massachusetts.

In addition to these census runs, one individual bird was watched

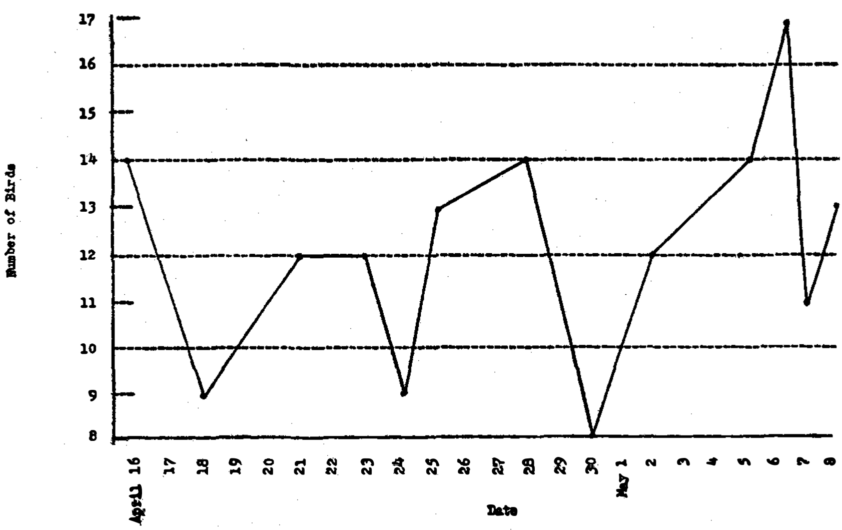

FIGURE 1. NUMBER OF SINGING MALE BIRDS COUNTED ON QUABBIN CENSUS RUN—1952

for 47 evenings and every activity each evening was recorded. By watching one bird, the variability between individuals was eliminated. The behavior pattern of this bird was supplemented by numerous observations of other individuals throughout the past three years. Variability seems the rule rather than the exception in the woodcock's breeding activity. This study will be referred to in the following recommendations for possible changes in census techniques.

RECOMMENDED CENSUS TECHNIQUES

Census methods of game are constantly in need of reexamination and changes incorporated in accordance with the latest information available. Since the following suggested census technique is based mainly on the studies in one area, it is offered as a basis for further discussion by woodcock coperators throughout the far-flung breeding territory of this bird.

It appears logical that, insofar as possible, the methods of counting woodcocks should be standardized. Factors causing variations should be reduced to a minimum. This would seem to be the first step toward putting annual woodcock inventories on a sound, statistical basis.

Briefly discussed, our studies suggest the following techniques:

Number of census runs. In the case of the census study route in Quabbin Reservation in 1952, the most conspicuous evidence of variability is that, of 28 runs made from early April until late May, no two found exactly the same number of birds in the same locations. In several instances, the total number of birds was the same, but in each of these cases some shifting about in specific locations was recorded. Taking the average of any three runs separated by at least two days between April 15 and May 10, the mean index would vary from nine to 15. The average of any six runs would only vary from 11.5 to 13. Similar analysis of the 1951 census and the census runs in Newburyport give roughly the same results. Wherever practical, therefore, six runs are recommended instead of the usual two.

Time length of census run. The records of the Quabbin census runs and the total minutes of performance each evening of the one individual bird observed give clues as to the length of time which should be devoted to a census run. Observations of others as well as Unit personnel indicate that during some evenings birds appear to perform for longer periods than others, especially on bright moonlight nights. To further standardize the census, everyone should run it for the same length of time and count no birds heard after a certain time. Tabulating 18 observations of the individual bird watched between April 15 and May 10, there was an average performance period of 34 minutes varying from 25 minutes to 44 minutes. These figures are based on the beginning of the first flight until the last *peent* after the last flight. This study and the census route studies suggest a running time of 34 minutes.

When to start run. Station One on a census route should be within hearing distance of a known occupied singing ground. Birds heard *peenting* in their diurnal cover should not be counted. In two locations in Massachusetts, for example, several birds could be heard *peenting* in a favorite diurnal cover. In one case, five birds could be heard, but only two used singing grounds audible to the observer. In the other case, three birds were heard *peenting,* but only one sang in the vicinity.

It is known that light intensity determines the moment when a bird will start singing. Light intensity can vary on a route in hilly country. The run should begin after *the completion of the first flight* of the bird at Station One.

Stop interval. Some experimental runs were made in Massachusetts stopping at 0.5-mile intervals instead of 0.2. With a 34-minute run and stops at half-mlie intervals, approximately 14 stations can be established over 5 to 6 miles of road.

Wherever there is a sufficiently long stretch of breeding habitat, it is recommended that stops be made at half-mile intervals for the following reasons:

(1) No duplication of count will occur the same evening. Trapping results indicate that only 20 per cent of the birds shifting territories in the same season will move a half-mile or more; thus, the duplication of counts due to such shifting of territories would be reduced to a minimum. In the overall picture, it is reasonable to presume that resident birds moving out may be counterbalanced by other resident birds moving in.

Secondly, more efficient use of an automobile is possible. A car can attain maximum safe cruising speed in a half-mile stretch.

Thirdly, a more representative sample of woodcock coverts will be censused.

Time duration of each stop. There was only one consistent behavior characteristic in the case of the individual bird observed in the spring of 1952. This was the time duration of each flight. Over 400 flights were timed, and the average time each evening varied from 51 to 63 seconds. Many other birds timed indicated that flight duration is seldom over a minute. The time spent by each bird *peenting* on the ground is highly variable. Intervals between *peents* are seldom longer than 10 seconds. An individual bird observed was timed on the ground between flights 223 times. On 28 per cent of these occasions, the bird spent longer than two minutes on the ground.

A uniform two-minute stop interval is suggested for each half-mile station. Only *peenting* birds should be counted. The reasons are that if one waits for a flight, he will often have to stop more than two minutes and thereby cut down on the number of stations which can be covered in one evening. Secondly, a bird in the air takes wide enough spiral flights so that one can hear him in the air on the perimeter of his circle, but he may be entirely inaudible when *peenting* on his singing field. Since he spends far more time on the ground than in the air, he would be missed more often than heard. If a bird is in the air when a car is stopped, one knows the maximum length of a flight is shortly over one minute. Therefore, a two-minute stop is of ample duration to wait until a flying bird lights, and then count him only if his *peenting* is audible.

Weather. Avoid taking censuses under any extreme conditions whether they be high winds, heavy rain, low temperatures or full moon. Insofar as possible, make runs on clear nights.

Other variables. Other variables may include:

(1) The different perceptiveness of different census takers. Audibility of individuals in some cases varied 30 per cent. (2) Interfering sounds, such as those of frogs. (3) Topography and density of vegetation. (4) The presence of avian predators (observed on two occasions to cause a cessation of *peenting*). (5) Several observation suggested the presence of a female on the singing ground stimulated flight performances. (6) Variations from one year to the next can sometimes be accounted for by a former singing ground becoming covered with so much vegetation that it "goes by."

SUMMARY

In summary, the Massachusetts studies have demonstrated that the promiscuous behavior of male birds is a dominant factor in causing variation in counts during the annual inventory period. Many males visit other singing grounds often not on the census route. Some variations in the count can be reduced by standardizing the method of taking a census. Recommendations include standardizing the interval between listening stations, the time duration of each stop, when to start counting, the time duration of the total run, the number of runs in a season and during what weather conditions to make a census. These suggestions are based on detailed studies of performing male woodcocks in central Massachusetts only.

ACKNOWLEDGMENTS

The results recorded above could not have been accomplished without the help of many individuals. Assistants over the past four years

include E. Howard, Jr., R. Wood, Wesley Jones, Gale Bennett, and J. Baird. Graduate students assisting in the study were F. Wojcik, W. A. Fitzpatrick, T. H. Ripley, and A. Pelletier. Outside cooperators include T. D. Ford, Gordon Hobart, Gardiner Hobart, L. Campbell, J. Taylor, R. Norris, Earl Smith, J. McDonough, W. Gunn, L. M. Bartlett, W. Nutting and Sargent Russell.

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DISCUSSION

MR. GOODRUM: This important paper that you have just heard on the census technique certainly bears some discussion.

MR. BRUCE WRIGHT (New Brunswick): I would like to ask Dr. Sheldon a question. Did you try to correlate your census numbers with actual production on the grounds by censusing the same area with bird dogs and counting broods?

DR. SHELDON: I made some attempt at that, but I didn't get sufficient data to get any correlation. Our broods are a little more difficult to find than they are in your New Brunswick area.

MR. GOODRUM: It seems appropriate that additional studies on census techniques that have been used for a good many years now should be made, and this paper demonstrates the value of re-examination of old techniques.

CHAIRMAN ERICKSON: I am going to ask Phil to introduce the next paper inasmuch as Mr. Redmond is speaking on the gray squirrel, the animal that Phil himself has done a good deal of work on.

MR. GOODRUM: The game squirrels cover a good many of the states, possibly through most all of the southern states and a good many of the eastern states, and the mid-western states. The squirrel is probably the No. 1 game species, yet there has been a tremendous amount of work done on most other species. For some reason or other, the squirrel seems to have been more or less neglected from a relative standpoint. Squirrels can take heavy hunting, equally as heavy as bobwhite in California, and yet we have very little data to show on that point.

I should like to point out that as far as I know, there has been practically no habitat development work or habitat improvement work for squirrels, although there has been a vast amount of work done for some of the other species.

This paper coming up now helps to give some additional information, some of the life history, which is badly needed. My own work on squirrels in Eastern Texas is down at the western end of the range, whereas Mr. Redmond has done his work in Mississippi. There has been some work in Alabama, but I don't think it has ever been reported; therefore, I think that this paper from Mr. Redmond might throw some additional light on the gray squirrel in Mississippi.

ANALYSIS OF GRAY SQUIRREL BREEDING STUDIES AND THEIR RELATION TO HUNTING SEASON, GUNNING PRESSURE, AND HABITAT CONDITIONS

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Mississippi Game and Fish Commission, Jackson, Mississippi

Over 79 per cent of the total holders of hunting licenses in Mississippi hunt squirrels. Following in importance, quail are hunted by 47 per cent of the total license holders. Although squirrels are of lesser importance in many other states, it is recognized that proper management techniques, inclusive of hunting regulations, are needed throughout the squirrel range. With this knowledge, the following information is presented on the southern gray squirrels (*Sciurus carolinensis carolinensis* and *S. c. fuliginosus*), which make up the major portion of the squirrel population in Mississippi.

METHODS

Data pertaining to life history studies, hunting methods, gun pressure, kill, and habitat studies, were obtained over a three-year period (July 1, 1949, through June 30, 1952) by the following methods and techniques: (1) collecting of laboratory specimens; (2) live trapping and tagging; (3) examination of leaf nests and den trees; (4) squirrel hunters' bag checks made with the assistance of twenty state game wardens selected to make bag checks; (5) mail questionnaires; (6) direct observations in the field.

Seven study areas were selected within the Pascagoula River Drainage Area for the purpose of making a detailed study. Three of these areas were protected from all types of hunting and four areas were open to hunting and were considered to receive the average amount of gunning pressure that all other public hunting lands received in the Pascagoula River Drainage Area. The study areas were cover-type mapped and a squirrel census was made periodically. All den trees were located and periodic checks were made on these trees. Records were kept on each tree by the use of "Nest or Den Tree Record" cards on which to record all pertinent information that could be obtained. Data on leaf nests were recorded in a like manner.

BREEDING STUDIES

Nest and den tree studies have yielded information on young gray squirrel as shown in Table 1.

TABLE 1. GRAY SQUIRREL LITTER DATA

Period[1]	Litters Examined	Total Young	Average Young Per Litter	Number Males	Number Females	Per cent Males	Per cent Females
July-June	24	57	2.38	30	27	52.6	47.4
July-June	31	85	2.74	44	41	51.8	48.2
July-June	59	142	2.41	75	67	52.8	47.2
Totals	114	284	2.49	149	135	52.5	47.5

[1]Fiscal years from 1949 through 1952.

TABLE 2. AVERAGE NUMBER YOUNG PER LITTER

Period	Placental Scar Count	Fetus Count	Nest Count
July 1949 - June 1950	3.11	2.54	2.38
July 1950 - June 1951	3.36	2.79	2.74
July 1951 - June 1952	3.27	2.85	2.41
Average	3.23	2.70	2.49

TABLE 3. THREE YEAR AVERAGE SHOWING AGE CLASSES AND SEX OF GRAY SQUIRRELS: EXPRESSED AS PERCENTAGES

	Male	Female	Adult	Juvenile	Adult Male	Juvenile Male	Adult Female	Juvenile Female
Personal Examination Records[1]	56.5	43.5	48.7	51.3	30.7	25.8	18.0	25.5
State Game Warden Examination Records[2]	56.6	43.4	49.2	50.8	28.5	28.1	20.7	22.7

[1]Based on 998 specimens.
[2]Based on 3,654 specimens.

A three-year average of placental scar counts, fetus counts, and nest counts reveals the following as shown in Table 2.

Graphs 1 and 2 are based on information obtained from the examination of 2,193 gray squirrels.

Graphs 3 and 4 are based on information obtained from the examination of 1,852 gray squirrels.

Graphs 5 and 6 are based on information obtained from the examination of 1,395 gray squirrels.

Age classes and sex of animals examined during the study are shown in Table 3.

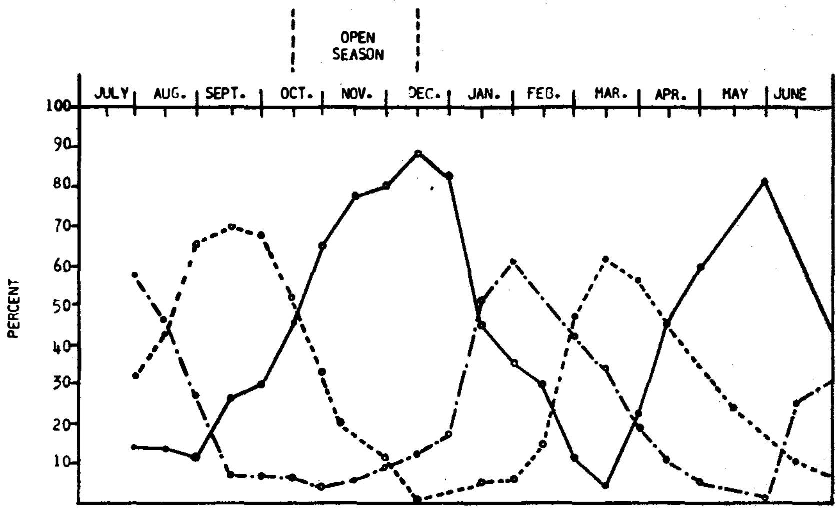
Live weights and dressed weights of squirrels examined are shown in Table 4.

TABLE 4. AVERAGE LIVE WEIGHTS A, AND AVERAGE DRESSED WEIGHTS INCLUDING HEADS B, 1949-51

	Adult Males	Adult Females	Juvenile Males	Juvenile Females
A				
Number Squirrels	221	241	247	248
Average Weights[1] (Ounces)	16.2	16.3	11.1	9.9
B				
Number Squirrels	102	101	148	101
Average Weights (Ounces)	9.8	9.5	7.1	6.6

[1]The largest adult male weighed 21.0 ounces and the largest adult female weighed 19.5 ounces.

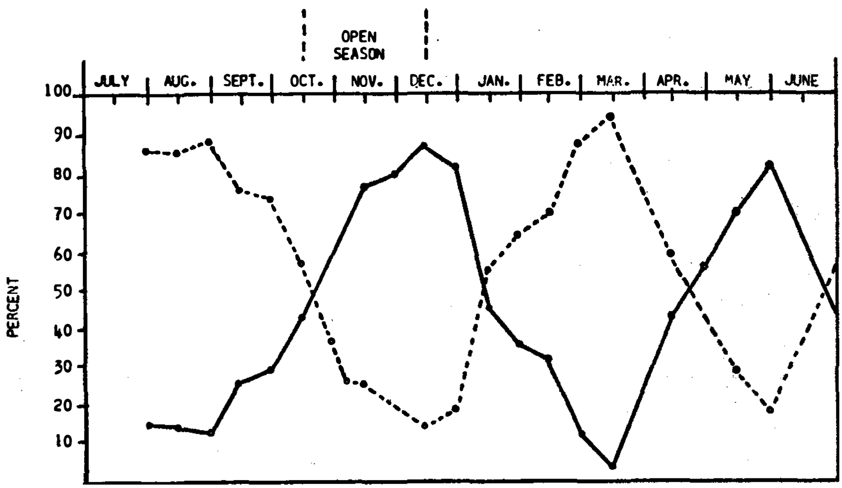
GRAPH 1. DATES-PERCENTAGES OF BREEDING CONDITIONS OF FEMALE GRAY SQUIRRELS (ADULT)



PREGNANCY —·—·— LACTATING -------- NON-BREEDING ———

PERIOD: AUG. 1, 1949 - JUNE 30, 1950

GRAPH 2. ADULT FEMALES BREEDING COMPARED TO ADULT FEMALES NOT BREEDING

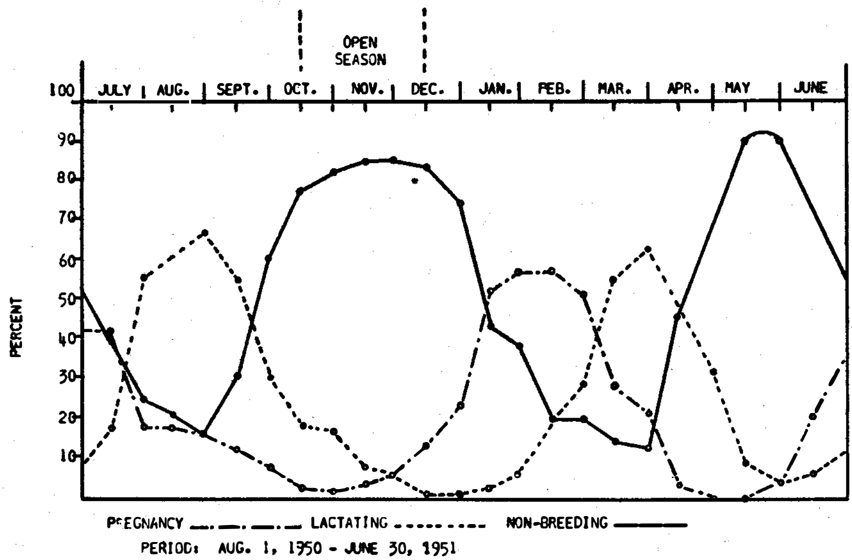


BREEDING (RUTTING, PREGNANCY, LACTATING) --------

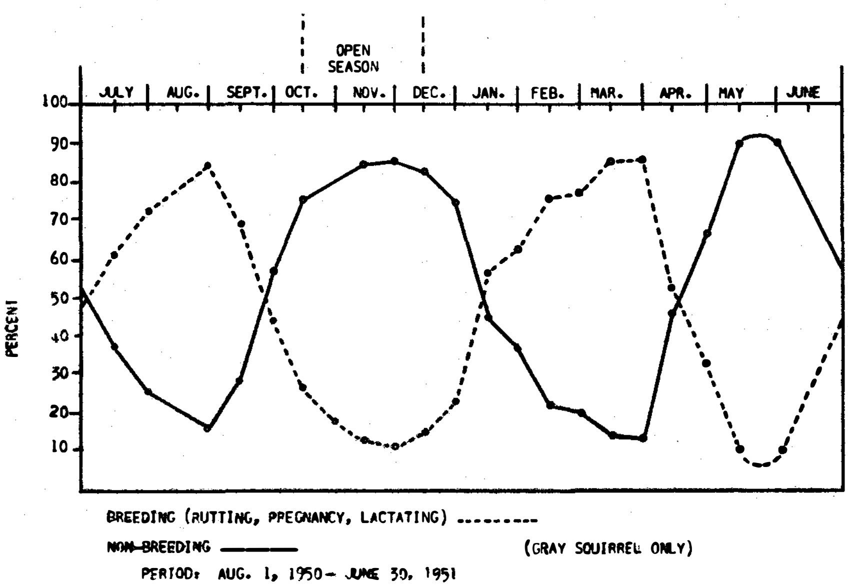
NON-BREEDING ——— (GRAY SQUIRREL ONLY)

PERIOD: AUG. 1, 1949 - JUNE 30, 1950

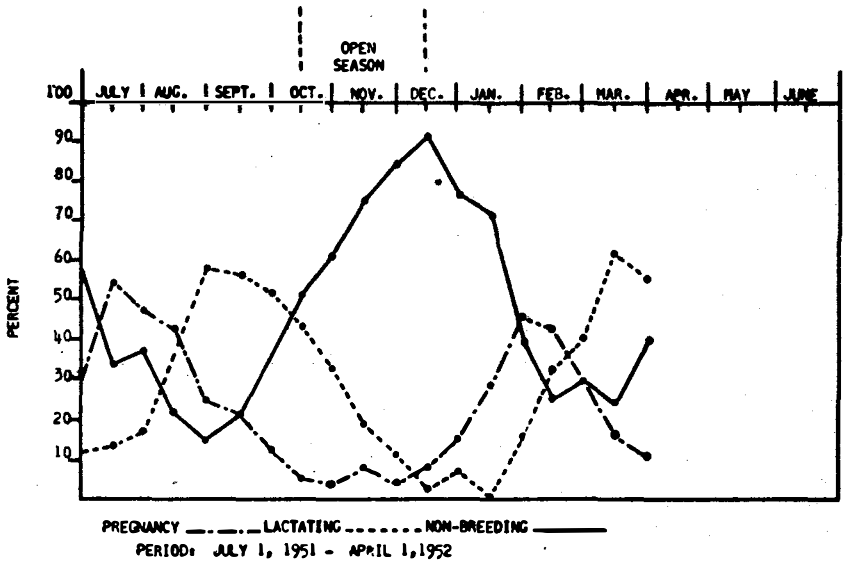
GRAPH 3. DATES-PERCENTAGES OF BREEDING CONDITIONS OF FEMALE GRAY SQUIRRELS (ADULT)



GRAPH 4. ADULT FEMALES BREEDING COMPARED TO ADULT FEMALES NOT BREEDING



GRAPH 5. DATES-PERCENTAGES OF BREEDING CONDITIONS OF FEMALE GRAY SQUIRRELS (ADULT)



GRAPH 6. ADULT FEMALES BREEDING COMPARED TO ADULT FEMALES NOT BREEDING

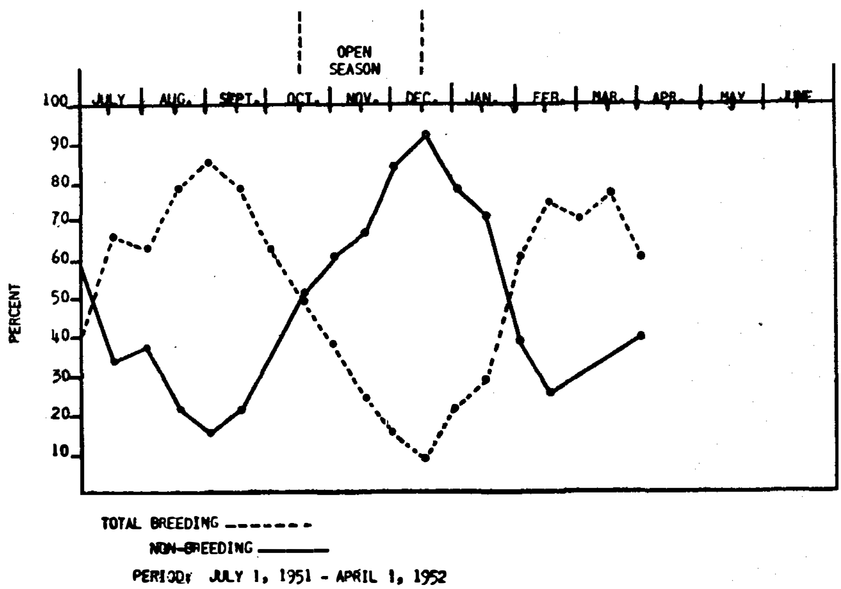


TABLE 5. HUNTING METHODS: EXPRESSED AS PERCENTAGES

Dates	Per cent Still Hunting	Per cent Using Dog
October 15-30	96.0	4.0
November 1-15	64.0	36.0
November 16-31	46.0	54.0
December 1-15	15.0	85.0
Three-Year Average	75.0	25.0

The gestation period of gray squirrels is approximately 43 days. Most of the young during the early breeding peaks are born in dens while those born during the last breeding peaks, August and September, are usually born in leaf nests. The lactating periods lasts from six to seven weeks. The process of weaning is usually complete when the young are 10 or 11 weeks of age, and after this the young must shift for themselves. The average number of young per litter is shown in Table 2 and the average number of litters per adult female per year has been found to be 1.6.

HUNTING METHODS, GUN PRESSURE AND KILL

The two major methods of squirrel hunting employed in Mississippi are still-hunting and dog hunting. Percentages of each hunting method used for the entire state at different intervals were determined from squirrel hunters' bag checks during the open hunting season and are presented in Table 5.

A three-year average from squirrel hunters' bag checks reveals that 3.7 per cent of the gray squirrels shot escaped crippled. This figure is considered somewhat low since only squirrels that were positively known to be crippled were reported. The average time spent per hunt effort was 2.8 hours. The types and numbers of firearms used by that segment of the squirrel hunters checked and reported by State Game Wardens are indicated in Table 6.

In addition to information on the types of firearms used, data were

TABLE 6. TYPES AND NUMBERS OF FIREARMS USED[1]

	Total Number For Three-Year Period	Per cent Of Each Type Used
12 gauge shotgun	1,468	66.65
16 gauge shotgun	263	11.94
.22 rifle	249	11.30
20 gauge shotgun	151	6.86
.410 gauge shotgun	61	2.77
.22/.410 gauge shotgun	5	0.23
28 gauge shotgun	2	0.10
10 gauge shotgun	1	0.05
.22/.12 gauge shotgun	1	0.05
.22 pistol	1	0.05
Totals	2,202	100.00

[1]Reported in Game Warden Bag Checks.

TABLE 7. LICENSE AND PERMIT USAGE BY SQUIRREL HUNTERS

	Three-Year Average
Hunters using license	88.9%
Hunters over age limit (65 years or over)	2.4%
Hunters under age limit (17 years or under)	3.0%
Hunters hunting on own land (No license required)	2.9%
Hunters using permit	0.1%
Hunters unknown (May or may not have license)	2.5%
Hunters hunting illegally	0.1%
Servicemen (No license required)	0.1%

also tabulated on the usage of hunting licenses and special permits. These data are presented in Table 7.

A questionnaire census of game kill in Mississippi was conducted by personnel of the State Game and Fish Commission for the year July 1, 1950 through June 30, 1951. From this survey, it was shown that squirrels were the most important species hunted. This is depicted in Table 8.

The estimated squirrel kill for each year of the study is shown in Table 9.

It can be seen in a comparison of Tables 8 and 9 that the total estimated squirrel kill figures for the year 1950 differ. This is a result of diffeernt numbers of hunters being used in the computations rather than an actual difference in total kill. The number of hunters shown in Table 9 represents total squirrel hunters, both licensed and unlicensed. The number of squirrel hunters in Table 8 is based on license sales only, hence the smaller figure. Approximately 11 per cent of the squirrel hunters in Mississippi do not use a hunting license.

The estimated kill, Table 9, for each of the past three hunting seasons indicates a decreasing population; however, in consideration of other factors, it is believed that the population is now holding its own or possibly increasing slightly. It was learned through field examinations that the largest kill was centered in those areas of the state where the mast production was highest, and the hunters' kill was heavier when the concentration was in the northern part of the state. The reason for this is believed to be a result of hunting method since the

TABLE 8. HUNTERS' SCORECARD RESULTS OF STATEWIDE GAME KILL, 1950-51

Species	Per cent Hunting Each Type	Number Hunters	Average Number Times Hunted	Average Kill Per Hunt	Average Kill Per Season	Estimated Total Kill
Quail	47.1	89,056	7.2	3.3	23.8	2,120,000
Squirrel	79.8	150,878	7.2	2.2	15.8	2,419,000
Rabbit	47.2	89,113	6.4	1.6	10.2	900,000
Raccoon	16.2	30,693	6.2	1.1	6.8	209,000
Possum	23.1	43,583	5.2	1.7	8.8	886,000
Dove	21.6	40,786	3.3	3.9	12.9	523,000
Ducks	9.0	16,226	4.8	2.4	11.5	182,000

TABLE 9. RESULTS OF THREE-YEAR SQUIRREL HUNTERS STUDY

Season	Per cent Licensed Hunters[1]	Per cent Squirrel Hunters Using Licenses	Total Squirrel Hunters[2]	Average Kill Per Hunt Effort	Average Number Times Hunted	Average Kill Per Hunter Per Season	By Species Gray	By Species Fox	Estimated Total Kill
1949	79.8	89.4	166,968	2.5	7.2	17.2	2,084,000	791,000	2,875,000
1950	79.8	89.2	166,773	2.2	7.2	15.8	2,024,000	605,000	2,629,000
1951	79.8	88.2	161,760	1.9	7.2	14.0	1,611,000	658,000	2,269,000
Three-Year Average	79.8	88.9	165,167	2.2	7.2	15.7	1,906,000	685,000	2,591,000

[1]The per cent of license holders hunting squirrels, as presented in this paper, compares favorably with the 80 per cent figure derived by Mr. St. Clair Thompson of this Department in a 1947 survey.

[2]The total number of license holders for the three-year period covered by this study was 187,068, 186,348, and 178,700 respectively.

hunter of that section prefers still-hunting and the number of still hunters is much greater than the number of dog hunters throughout the state. Adverse hunting conditions during the past hunting season were responsible for the decrease in the total kill. This was to the advantage of the squirrel population since field observations by the writer and state game wardens' reports indicated a larger number of squirrels left throughout the state than was left during the previous years.

Adverse hunting conditions were experienced during the open season, October 15, through December 15, 1951. A period of unusually dry weather prevailed during the first three weeks. It is estimated from squirrel hunters' bag checks that about 80 per cent of the total harvest is normally taken during the first two weeks of open hunting season, and about 5.0 per cent during the closing week. Still-hunting is very unsuccessful in dry weather except, where there are large concentrations of squirrels. Under these conditions, it is seen that squirrel hunting pressure during the 1951 season was possibly much lighter than normal.

HABITAT STUDIES

Seven study areas representative of South Mississippi types of squirrel habitat were selected for detailed study. A general description of the areas is as follows:

The topography is of the rolling hill type. Longleaf pine is the dominant tree species on the ridges, and hardwoods are dominant in the lowlands. This entire area was stripped of virgin longleaf pine over 20 years ago. Many of the typical longleaf pine sites have been invaded by hardwoods. Young longleaf pine stands still occupy the larger portion of the area. The soil is sandy loam with a clay subsoil. Numerous small farms scattered throughout the area have an average of 30 years per farm in cultivation. The main agricultural crops are corn and soybeans. Some livestock farming is also undertaken. Although improved pastures have become more common in recent years, cattle and hogs, the chief livestock raised, still graze for the most part on open forest land. With a continued increase in improved pastures and with the discouragement of open range grazing on public lands, it is believed that within a relatively short period of time uncontrolled livestock grazing wlil not be permitted in the forest. This will be advantageous both to the squirrels and to the forest. At present, food is not a limiting factor in this region.

This region possesses three major types of squirrel habitat. They are: (1) bottomland hardwoods, (2) mixed upland hardwoods and pine, and (3) longleaf pine. The bottomland hardwoods are the most important type for gray squirrels and are composed chiefly of the following tree species: swampbay (*Persea palustris*), magnolia (*Magnolia grandiflora*), beech (*Fagus grandifolia*), blackgum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), and other wetland species. Along the borders are hickories, pines, and other species. Nearly all of the gray squirrel den trees were found within the swamp in this bottomland type.

Mixed upland hardwoods and pines are of great importance in the fall because of the mast crop which they produce. The main trees found in this habitat are scrub oaks, red oaks, hickories, and pines. There are dogwoods (*Cornus florida*), chinquapin (*Castanea* sp.), and winter huckleberries (*Vaccinium arboreum*) scattered throughout this habitat. Very few den trees were found in this type. In September, October and November, gray squirrels were found using this type extensively during the day and returning to the bottomland hardwoods at night where den trees were available. During the latter part of November, the squirrels began to desert this type almost entirely and occupied the bottomland hardwoods altogether.

The longleaf pine type was found to be of little value to gray squirrels, but appears to be the habitat most used by fox squirrels, especially when there are scattered hardwoods and dens present. This type is composed of pure stands of longleaf pine (*Pinus palustris*) with occasional hardwoods appearing within the stand. These hardwoods may be any of the upland hardwoods native to South Mississippi.

Considerable information pertaining to habitat requirements, carrying capacities, and other pertinent information was obtained from the above-mentioned study areas. Although this information is not included here, it was used as part of the basis for some of the conclusions and recommendations presented.

MANAGEMENT RECOMMENDATIONS FOR MISSISSIPPI

1. Maintain a state-wide hunting season with the same opening and closing dates.
2. It is recommended that the squirrel hunting season extend from from October 15 through December 15, both dates inclusive. It is recognized that November 1 through December 31 is most biologically sound from the standpoint of breeding females; however, it is believed that other factors will justify the recommended season.
3. Bag limits: Five squirrels per day.
4. It is recommended that an average of two den trees per acre be maintained in bottomland hardwood areas.

5. Make yearly squirrel hunters' bag checks in at least 20 counties well distributed over the state, to estimate total annual kill and population trends.

SUMMARY

1. There was a total of 114 litters of young gray squirrels examined, of which there were 284 young, giving an average of 2.5 young per female. The sex ratio was 110 males to 100 females.
2. Placental scar counts of 197 adult female gray squirrels gave a total of 637 scars or an average of 3.2 per female.
3. Fetus counts of 105 pregnant gray squirrels gave a total of 284 or 2.7 young per female.
4. Breeding percentages were determined periodically and graphs were drawn to show the breeding peaks throughout the year.
5. Percentages of age class and sex were determined.
6. A three-year average of squirrel hunters' bag checks revealed the following information:
   (a) The average time spent per hunt was 2.8 hours.
   (b) Seventy-five per cent of the total squirrel hunters were still-hunters and twenty-five per cent used dogs.
   (c) The average kill per hunt was 2.2 squirrels. From squirrel hunters' bag checks, 3.7 per cent of the gray squirrels shot were known to have escaped injured.
7. A. According to a questionnaire census of game kill in Mississippi, there were 150,878 squirrel hunters comprising 79.8 per cent of the total license holders. The estimated total kill was 2,419,-000 squirrels.
7. B. According to the three-year average of squirrel hunters' bag checks, the average kill per hunt effort was 2.2 squirrels. The total average kill was 2,591,000 squirrels.
8. Habitat studies revealed that:
   (a) Pine type has no value in maintaining a gray squirrel population.
   (b) The mixed upland hardwoods are of greater importance because of the food available in the fall.
   (c) The bottomland hardwoods type is considered to be essential in maintaining a stable squirrel population in South Mississippi.
9. The common dog tick (*Dermacentor* sp.) was found to be the most serious external parasite.
10. The species of squirrels found in Mississippi are: (1) the southern gray squirrel (*Sciurus carolinensis carolinensis*), the Louisiana gray squirrel (*S. c. fuliginosus*), (2) the hill fox squirrel (*S.

niger bachmani), and the "Delta" fox squirrel (*S. n. subouratus*).

11. Immigration was found to be a result of food shortage and the annual shuffle. These movements are more often mistakenly called migration.

DISCUSSION

MR. GOODRUM: Do you have any comments on Mr. Redmond's paper?

MR. UHLIG (West Virginia): I would like to know if Mr. Redmond has any data as to what per cent of his young squirrels come from a spring litter and what per cent of his young squirrels come from a fall litter.

MR. REDMOND: We have been doing such work for the last four years and have found that 45 per cent of our juveniles are from spring litters.

MR. UHLIG: How did you determine the 1.4 litter figure that you gave?

MR. REDMOND: I have information on that. I don't have it with me, but we have only a fall hunting season, October 15 through December 15. At the close of that season, the adult female population is greatly reduced, the females which will become adults just for the late summer breeding peak. Therefore, I found that we had a larger percentage of adult females of the total adults breeding during the first peak, that breeding which comes off approximately March 15. It is due to those juveniles that were born that time the year before.

The 1.6 average litter per year was determined from tracking operations on two of my protected study areas. By tracking the juvenile females I got that one area, which I maintained by artificial feeding, and that population remained constant almost through my study.

What I mean is, there were no squirrels lost at all by emigration in the fall. By having certain females which I examined, I determined if they were lactating in March and again in the fall. Whether they were lactating or not, I tried to handle those squirrels enough so that I could tell during the breeding year whether they had produced young. By handling a number of squirrels over a period of time, say a hundred squirrels—you might handle them each season—you can determine what percentage breed twice in a year.

MR. GOODRUM: I would like to ask Mr. Redmond to give a quick resume of one other point. I believe he did give the figures. I would like for him to tell briefly when the two peaks of production of young breeding occurred.

MR. REDMOND: I can best give that by my curve on total breeding females. That included pregnancies and lactating. I also have a short graph showing pregnancy separated from lactating and then non-breeders, but the first peak in the total number of breeders produced was reached March 15. The latter breeding peak was reached around the first two weeks of September, with the lows coming the last week in November and the last two weeks of May.

MR. GOODRUM: Unless there is any more discussion, we will move on to the next paper.

CHAIRMAN ERICKSON: Our next paper is by William H. Marshall of the University of Minnesota. In July, 1952, Dr. Marshall returned from his Sabbatical leave to his professorial duties. During that year he had been with the Wildlife Management Institute to study and find out something about the wildlife plans that had been going on for a number of years in the eastern and southeastern states. He is going to tell us about his experiences during that period of his leave from his university work.

A SURVEY OF FARM-GAME HABITAT RESTORATION PROGRAMS IN FIFTEEN STATES[1]

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For at least twenty years the thinking of wildlife managers has been directed toward the importance of habitat in producing surplus game populations for hunting. The decline or disappearance of game populations — often over considerable areas — following changes in habitat brought about by agricultural, urban, or industrial developments demonstrates clearly the effects of the elimination of desirable habitat. Suitable habitat is basic to the survival of wildlife. Many field observations and experiences, as well as specific data from research, validate this conclusion. Where a harvestable surplus of game cannot be maintained because of changes made by man in the habitat, the obvious answer is: *Restore the habitat.* There are many practical and fundamental challenges to this objective.

As this principle gained support, funds needed for habitat improvement were made available to the states with the enactment of the Federal Aid in Wildlife Restoration (Pittman-Robertson) Act of 1937. State Fish and Game Departments immediately began or expanded studies on the ecology and management of wildlife species, and projects designed to restore habitat soon were initiated. After a general curtailment of these programs during World War II, the states reactivated or initiated more extensive programs after 1945. By 1951 the majority had made habitat improvement a major feature of their programs.

Much of the emphasis in habitat restoration has been placed on farm-game species. There are several reasons for this—both basic and superficial. When conditions are favorable to wildlife, fertile agricultural areas are highly productive of farm game. Species in this classification have a high reproductive potential and a relatively low mobility. As expressed in the annual hunter-kill reports of most states, farm game is more readily available to a larger number of hunters than other classes of wildlife. The existence of a land-use program through soil conservation districts creates convenient administrative channels.

Although six years is a short time to show results in any program dealing with ecological changes, the present report outlines the conclusions reached in an attempt to evaluate current farm-game habitat

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development programs in fifteen states. Actually to these six years must be added the experiences accumulated from about 1933 through 1945, even though the earlier activities may have been more sporadic and piece-meal than since that time. The work was carried out between October 1, 1951 and June 30, 1952 and the following states were visited: New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Florida, Georgia, Alabama, Kentucky, Indiana, Illinois and Missouri.

METHODS

A program as important as farm-game restoration needs all the attention it can receive. It was thought that a review by a person acquainted with the fundamental concepts, but not closely bound by personal or administrative considerations, could point out the accomplishments and loopholes in the programs. This the author has attempted.

The approach to this survey was almost entirely qualitative and the evaluation was based on visits in the field to actual habitat improvements. Following a preliminary discussion with Wildlife Management Institute, U. S. Fish and Wildlife Service, and U. S. Soil Conservation Service personnel in Washington, D. C., visits to Pittman-Robertson projects in the various states were arranged. The program for each state was discussed with the project coordinator, and an itinerary, usually involving an entire week, was arranged with various field personnel. The itineraries attempted to include the following: (1) the oldest habitat restoration work in the state, (2) the areas showing most intensive development, (3) areas representative of different agricultural uses, and (4) field research projects on farm-game habitat programs. As a final step, reports on the trips were submitted to each coordinator for comment. These comments were returned to the author before preparation of the present over-all report.

Because most farm-game habitat improvement projects are scattered widely, a true random sample survey would have been very time consuming. The inadequacies of quickly surveying an extensive state program in New York, South Carolina, or even New Jersey are realized. However, significant portions of the program in most states were discussed and seen and a concept of the operations obtained in this way. Further, in general, the better plantings were seen and visited with the responsible personnel. This is not to imply a conducted tour of only the best. In most instances, accomplishments were seen as they came, and frankness was the rule rather than the exception.

I wish to acknowledge the whole-hearted cooperation of state personnel in almost every case. The most pleasant part of my experience

was the real sense of responsibility and honesty in thinking encountered in the field. The Wildlife Management Institute, through Dr. Ira N. Gabrielson and C. R. Gutermuth, encouraged the study and made it possible. The University of Minnesota readily granted a nine-month Sabbatical furlough. James Trefethen ably and generously assisted in the preparation of the reports. Several other persons, notably Walter Rosene, critically reviewed this final report.

STATE PROGRAM OPERATIONS

The objective of the state programs is the development of food and cover in areas where one or both are missing. The present trend is to stress planting of materials in small plots which can be spared from farming operations. In these cases there is a desire to use plants which should be permanent additions to the landscape and which will grow where agricultural crops do not thrive.

Although the operating systems of the fifteen states differ in many ways, each depends to some degree on the cooperation of one or several agricultural agencies. The amount of dependence appears to vary inversely with the size and age of the program. There are four general types of systems.

Ten state projects are working primarily through soil conservation districts. Usually field biologists spend considerable time with employees of the district offices instructing them in the needs of wildlife and in the use of materials supplied free of charge by the state project. Estimates of needs are obtained from these workers, and materials are delivered to the offices for further distribution to farmers. In some cases the plantings are part of a farm plan, in others the plants are used on areas where game production is uppermost in the landowner's mind. Site preparation, local distribution, planting and subsequent care are provided by the individual landowners with little supervision by trained personnel. A variation of this system is used in New York where crews employed by the soil conservation district do the actual work; the farmer is charged a standard price per unit for work performed; and the State Conservation Department reimburses the District for all costs above this price.

One state is using primarily a demonstration method. In Missouri, the project, following a widespread establishment of demonstration plots using plants or practices having both agricultural and wildlife values, attempts to develop further interest by first providing materials free to farmers, and then shifting to sale of materials to persons attracted by the first two steps (Biffle, 1951). Workers in this state report that they have completed this change with Korean lespedeza, farm ponds and multiflora rose. The serecia lespedeza program is well into the free-distribution stage.

Two states are doing most of the work with their personnel. In Delaware, state crews do the planning, preparing, and planting of sites on individual farms. Work is most intensive in selected areas around state-owned and developed tracts where landowners are brought into the program by direct contact. Pennsylvania workers carry on limited habitat work on certain areas designated as Farm Game Projects. A great proportion of this project's work consists of posting safety zones, operating special patrols, and distributing ryegrass seed or other materials as a service to the farmers in return for their keeping the project areas open to public hunting.

Three states are working on what might be called special areas. In New Jersey, where human population pressures and the attendant problems are most intense, the project provides materials and close supervision of development work on specific areas where access is controlled by hunting clubs, sportsmen's groups or individuals. The programs in Maryland and Indiana stress intensive development of small refuge areas on farms reached by contact through soil conservation districts or other means. In Indiana a written ten-year lease is executed for each tract and recorded with the property title.

There are many types of supplementary projects. For example, Indiana workers, in addition to the development of special areas, carry out a large multiflora rose distribution program. Most states encourage sportsmen's groups to improve selected areas, and sometimes the development of public hunting grounds is linked closely with the general farm-game program.

SPECIFIC PRACTICES

Each state program utilizes one or more specific practices of habitat improvement. Simplicity in (1) administration, (2) technique used and (3) means of applying the technique on the land appears to be a primary objective in most cases. With this simplicity, large programs, as to numbers of plants distributed and areas treated, can be inaugurated quickly and results reported in short order. There follows a listing of practices observed with an indication of the magnitude of these programs and their regional locations. The problems encountered in this survey are discussed.

Shrub and tree planting.—The planting of nursery stock is the backbone of most programs. In general, such stock can be produced quickly, units can be tallied and reported individually, distribution is relatively simple and a concrete entity is delivered to the farmer. The latter point has definite psychological advantages. Many project workers also cited that the distribution of shrubs called attention to their importance as a desirable type of vegetation in contrast to grass, cultivated plants, or trees which always have received much publicity.

Shrub Lespedeza (*Lespedeza bicolor*) is the most important species in use on farm-game projects in terms of numbers of plants distributed. In the states visited, about 27 million seedlings and 40,000 pounds of seed were distributed during the 1951 planting season (Warvel, 1951). Six southern states—South Carolina, Georgia, North Carolina, Alabama, Virginia and Kentucky—each had distributed between one million and eight million plants. Delaware, Maryland, Florida, Missouri, and Illinois had used these plants in smaller numbers. However, it seemed apparent that numbers of plants alone provide a poor criterion of the real value of this practice.

The distribution of shrub lespedeza plants and seed in large quantities is primarily through the local soil conservation district offices, although in some cases game wardens and county extension agents play important roles. Usually a game department truck, manned by field biologists, delivers a county quota to the office in question, and farmers or landowners come to this office to obtain the materials. The individual is expected to plant them in sites selected previously as part of a farm plan or game program. The sites are assumed to have been prepared in advance.

The reasons for this popularity are several. The seeds of shrub lespedeza are eaten readily by quail. They drop to the ground throughout the winter months and are said to be available during this entire period. The plant is considered to be a relatively permanent addition to the landscape due to its own longevity (Davison, 1949). Most field workers think of it as capable of withholding the invasion of trees and other woody plants. Seedlings are produced in one year and can be handled efficiently in large shipments.

There appear to be several serious limitations to the ultimate value of present extensive shrub lespedeza programs which will be discussed briefly as immediate and long-term problems.

First to be considered is the actual survival of the plantings. Three states have conducted checks on first-summer survival. In North Carolina a 10 per cent check determined that 61 per cent of the plantings had a plant survival of 70 per cent or better. South Carolina personnel checked 14 per cent of the 1950 plantings and found that 69 per cent of the plantings survived 60 per cent or better. In Virginia, interviews with 10 per cent of the farmers planting shrub lespedeza in 1950 revealed that three-fourths reported a survival of 75 per cent or better (Little, 1951).

The causes of failures listed in these studies were: Materials not delivered (3 per cent in North Carolina), materials not planted (13 per cent in North Carolina, 25 per cent in South Carolina, and 9 per cent in Virginia), poor survival (23 per cent in North Carolina, 5 per cent in South Carolina, and 25 per cent in Virginia) and poor planting pattern (1 per cent in South Carolina).

Two states have made surveys which checked survival for several years. Kentucky biologists checked 869 plantings and considered 38 per cent successful, 42 per cent unsuccessful (due to being too small in size) and 20 per cent failures. Over a four-year period 69 per cent of the plantings in Florida have been checked and reported as 8 per cent excellent, 12 per cent good, 37 per cent fair, and 43 per cent poor. Kentucky's standards are very high, and the 42 per cent classed as unsuccessful due to small size would have been judged successful in other states. Florida, as a result of its studies, is shifting to other plants.

There is a more important question which must be considered; i.e. whether or not the plantings are located where they are of value to game. This has two aspects: (1) Where several elements in the habitat are missing, the shortage of winter food may not be the limiting factor. Shrub lespedeza planted between large fields and dense woods or in small plots in grazed areas may not be of value if there is a widespread deficiency in nesting or roosting cover; or (2) plants may be placed in areas where there already is an adequate winter food supply. For example, during the survey, many stands of shrub lespedeza were seen in areas where Korean lespedeza was growing profusely. Inasmuch as both plants are reportedly winter foods for quail, the efficiency of special plantings of shrub lespedeza under such conditions seems doubtful. In the author's opinion these are serious questions that merit quantitative answers. In some areas—notably the tobacco region of south-central Virginia—where there is a wide variety of intermixed cover types, quail sign was common in the shrub lespedeza plantings. In many areas it was not.

Choosing locations where best growths can be expected seems as important as proper location for quail use. Shrub lespedeza has been expected to grow on soil not useful to agriculture and the large distribution programs tend to place it on spots which are not in crops for a variety of reasons, chiefly low fertility. To be sure, fertilization is recommended for good growth of the shrub. However, the report of the Virginia survey states that only 60 per cent of the farmers applied fertilizer at the time of planting. Two statements were obtained on the fertility requirements of the plant. One worker in Alabama said he believed that the soil fertility must be equal to that required for corn, and another, in Missouri, said that good alfalfa soil was necessary. Many cases of shrub lespedeza making very poor growth due to low site quality were observed.

Based on impressions gathered during the field work, it is estimated that deficiencies in planting, low survival, and poor location of plantings reduce the initial significance of the plantings by 50 per cent.

Field observations and discussions during the present survey show that there are various limitations on the long-time values of shrub lespedeza. The plantings have been regarded as permanent additions to an area, but this assumption is not always valid.

The plant in question is a shrub. In the Southeast, plant succession toward forest types is a vigorous process. Pines, red gum, sassafras, and Japanese honeysuckle are particularly rapid invaders of brushy areas. Except for plantings on the Pokemoke State Forest in the eastern shore of Maryland, this survey failed to find border plantings ten years old or over that were not giving ground rapidly to woody plant invasion. Many plantings, five to ten years old, were found to be succumbing. Especially striking examples of invasion by honeysuckle were seen in the Piedmont areas of Maryland, Virginia, North Carolina, South Carolina, and Alabama. Cases of rapid invasion by pines, red gum and sassafras also were seen. Certainly, here is a real problem.

Another factor is the quantity of seed production by shrub lespedeza plants even though no plant invasions take place. Here again no data are available, although a Missouri worker states: "The plants fall off in their seed production just as soon as the available nutrients fall below the minimum necessary . . . this may occur in the tenth, seventh, fifth or as low as the third year. . . ." It appeared that many plantings seen in all states were losing seed production by their fifth year. When it is remembered that significant seed production often does not start until the second or third year, the useful life of such plantings is indeed short.

The various types of deterioration can be overcome, for a time at least, by maintenance practices such as cutting, chopping, disking or burning and then fertilizing the stands at intervals, (Rosene, 1952). The most striking demonstration of the values of such work was seen near Providence Forge, Virginia, where bulldozing part of a five-year-old stand for landscaping purposes resulted in the elimination of invading woody plants and vigorous sprouting of the shrub lespedeza. The necessity for maintenance is recognized and these practices are being carried out on certain state-owned tracts and shooting preserves. However, maintenance work is not being carried out as a part of the extensive programs on farm lands in most states. In many cases field technicians were not aware of the importance of this problem in their areas.

Still another facet of the long-time problem that appears important is the life of the planting in the face of farming practices. All too often, particularly in tenant farming areas, established shrub lespedeza borders had been destroyed by the plow or by grazing. In many areas the farm hand has been trained, over a long period of years, to "brush out the field borders." To these men shrub lespedeza was so much brush and, even though instructed otherwise, they forgot to follow orders.

When one considers these longevity problems, it appears that the present programs must be devaluated at least another 25 per cent. This leaves, at best, a 25 per cent positive result for, perhaps, five to ten years.

Growth habits of individual shrub lespedeza plants on the coastal plain and Piedmont regions of the southeastern states were strikingly different from those observed in Kentucky, southern Illinois, and Missouri. East of the Appalachians growth was heavy, with annual resprouting from the main stems at varying heights. To the west, growth was lighter and regrowth each year was almost exclusively by basal sprouts. East of these mountains seedlings were found in only one case, while in the west seedling production was observed in nearly every stand of shrub lespedeza more than two years of age. On the basis of this survey, no significance can be attached to this difference, except that early developing grasses seemed to be affording serious competiton to the basal sprouts in the western plantings. The difference does demonstrate that the transfer of a practice from one region to another may bring about different plant reactions.

Multiflora Rose (*Rosa multiflora*) was second in importance in terms of numbers used during 1950-51. About 13 and one-half million seedlings had been distributed in the states visited. Workers in Indiana, Missouri, Illinois, and New York distributed two and one-half million to four million plants. Other state projects using this plant are Kentucky, North Carolina, Maryland, New Jersey, Pennsylvania, Delaware, and Florida. The Virginia Commission has an announced policy of not using the plant. Multiflora rose is not used in South Carolina, Georgia, and Alabama.

Multiflora rose seedlings are being sold at about cost by all of the leading states. Frequently distribution is direct to the farmer by express or mail instead of through soil conservation district or other offices. Mass production and distribution techniques have been well developed. Here is another broadcast distribution system but with the advantage of a direct farmer economic interest.

The reported values of multiflora rose are primarily agricultural although Wandell (1948) cites notes on its use by pheasants, cottontail rabbits, and songbirds, while Edminster and May (1951) state, "It is a first-rate wildlife cover plant" and "The fruits . . . provide good food for pheasants and many other birds."

There are few data on survival of multiflora rose plantings. Missouri Field Service Agents inspected 879 plantings of the 1950 season and reported 67 per cent survival. A similar inspection of 1951 plantings indicated that 76 per cent of 90 plantings survived. In 1951 Commission biologists inspected 478 all-age demonstration plantings (planted by Commission personnel on private lands) and rated 73 per cent as good to excellent, 15 per cent as requiring at least six years to become stockproof and 12 per cent as never becoming stockproof. It is interesting to note that the range of survival is similar to that shown by the surveys of large shrub lespedeza programs.

Longevity of plantings appears to be no problem. The 22-year-old multiflora rose plants at the Greys Summit Arboretum in central Missouri are about 9 feet high and spread over an area 15 feet in diameter. About a dozen ten-year-old plantings seen in Missouri were growing to similar proportions. A hedge established in 1938 in eastern Maryland had grown profusely until its height averaged eight or nine feet and the width 12 to 14 feet. On the other hand, a four-year-old hedge in Montgomery County, Maryland is being eliminated by Japanese honeysuckle. This latter plant may be a problem with rose as well as with shrub lespedeza.

There are two opposing aspects to the problem of survival and longevity of rose. First, do the plants survive and grow well enough to justify their use, and second, do the plants grow so profusely as to become a pest? These aspects appear to have distinct regional connotations.

In the northern and midwestern states it appears that survival is the problem. Quality of site preparation is all-important here as seedlings are vulnerable to weed and grass competition and require high fertility for rapid growth. All states distribute planting instructions emphasizing site preparation by plowing, disking and fertilizing. Care for the first two years by use of mulches, protection from grazing and replanting "skips" also is stressed. Nevertheless, frequent cases of poor hedge development were seen. This appeared more evident in the states which had inaugurated rose distribution most recently.

In the seaboard states, particularly the more southern ones, the question of this rose becoming an important agricultural pest occurs. Rosene (1950) points out the need for caution. Old plantings of multiflora rose, seen in Maryland (eastern shore), eastern Virginia and Georgia, as well as the Cherokee rose (*Rosa laevigata*) in Alabama, are living demonstrations that caution is of extreme importance. The vigorous growth of young plantings and the occurrence of branch runners in North Carolina plantings add to this impression.

Although implications have been made than the thorny, upright variety of multiflora rose plants is being distributed and that these plants have remained in place for dozens of years without spreading (Edminster and May, 1951), all older plantings seen in the eastern seaboard area during this survey demonstrated otherwise. In fact, rose has spread very considerably at the site pictured in the publication mentioned. Actually, the validity of the variety may be open to question as, under the pressures of the rapidly expanding program, nursery men have taken seed wherever and whenever convenient. Since this plant is cross-pollinated, considerable variation in seedlings can be expected under these conditions. Variations in flower character and growth frequently were seen.

Basic ecological differences as expressed in differing plant climaxes may be of vital importance in this problem. In Kentucky, Illinois, Missouri and Indiana, where *conditions leading towards a prairie climax exist,* rose growth appears less luxuriant and spreading seems less active. In the seaboard states, extremely rapid growth, climbing, shoot runners and active spreading by seed were seen. These *areas are those of a forest climax.* Perhaps the plant responds differently to the environment in prairie and forest areas. Field workers in Indiana and Missouri stated that spreading was more common in the southern forested sections of those states. It appears clear that transfer of midwestern data to the east coast is risky in this case.

More fundamental to the problem of multiflora rose is: What are the wildlife values of the plant as used in these distribution programs? Granted, it looks better to the wildlife manager than a barbed-wire fence. How much better is it, under what conditions, and to what wildlife? Heavy use of young plantings by cottontails was seen in Missouri and North Carolina, but, this may have been a reflection of the fertilizer added at the time of planting. During May, pairs of bobwhite were seen in the vicinity of hedges in Missouri and Illinois, but, ample herbaceous cover was available at this time. Pheasants have been reported as surviving on the fruits of rose under pen conditions (Johnson, 1951). During the survey, only one instance of direct evidence of pheasants using the fruits in the wild was reported and this under what was judged to be starvation conditions. Data on these questions are lacking in a year when 13 million rose seedlings were distributed as a wildlife management measure.

The concept in Missouri is that rose hedges would serve as "tie-in" cover or travel lanes between stream bottom and woodlot cover of the northern Ozark Plateau. It was learned that wildlife use of isolated fences or patches is scant. In pasture areas of other states rose hedges of a half-mile or more in length were seen extending between pastures and/or cultivated fields. How much of these hedges will be used by wildlife?

The duration of the cover values to wildlife is unknown. The ground underneath a well-established hedge becomes bare. There are no data to show whether the changes in a maturing rose hedge affect use by wildlife species. In some areas the drooping branches are being mowed at heights of a foot and over to combat spreading. Hedges treated in this manner were judged to be of low wildlife value.

Conifers rank next in importance in habitat restoration programs primarily because of the more than nine million trees planted in New York. Illinois and Pennsylvania have each planted about a million trees. Other states using conifers are Indiana, Maryland, New Jersey and Delaware. When added to the above, the total planted in the states visited was about 12 million trees.

Coniferous growths usually are planned to add winter cover in areas of extensive deciduous growths or open fields in the more northern states.

The New York program appears outstanding for several reasons. First, the conifers used were those for which the foresters already had well-developed nursery and planting techniques. Second, the program fits into the economics of land abandonment in the southern parts of the state. Third, the farmer pays for the planting of trees by planting crews thus insuring uniform planting. Fourth, cutting for Christmas trees and lumbering, by keeping the stands broken up, may well prolong the usefulness of the planted areas for wildlife. A final and most important reason is that the program appears to fit ecologically.

With regard to the ecological aspects, in practically every one of some 90 examples seen, the relatively small plantings (upper limit 10,000 trees) were islands of coniferous cover in an expanse of brushlands, hardwoods and/or agricultural land. There is ample research evidence of the use of such areas by ruffed grouse, snowshoe hare, cottontail and deer.

The major danger with the use of conifers appears to be the possibility of overplanting areas with the result that subsequent maturity of the stands practically eliminates ground cover. Where utilization of the trees at an early age for Christmas decorations, mine timbers, or pulpwood can be developed this danger subsides. The difficulty appears acute particularly where small brushy areas in primarily agricultural regions are planted solidly to conifers. One such area in northern Indiana had reportedly not been used by pheasants the previous winter although the adjacent weakly growing weeds of a fence row were utilized.

Shrubs are being distributed by several states. The most common plants in use are silky dogwood (*Cornus amomum*), Tatarian honeysuckle (*Lonicera tatarica*), hybrid hazelnuts (*Corylus* spp.) and highbush cranberry (*Viburnum trilobum*). Pennsylvania and New York distributed most of the one million plants reported used in 1951. Other states using these plants are New Jersey, Illinois and Maryland.

These shrubs are described as sources of wildlife cover and fall foods (Edminster and May, 1951.) No field data are available on survival or use by wildlife of these plantings as used in the states.

There seemed to be several serious ecological questions involved in the use of such shrubs. Not infrequently, native brush species are cleared off or at least ignored in planting these shrubs. In one state silky dogwood often was planted in or adjacent to native stands of the similar red osier dogwood (*Cornus stolonifera*). In other locations plants such as blackberries (*Rubus* spp.), hawthorn (*Craetegus* spp.) and similar native fruit-bearing plants were growing vigorously on or adjacent to the planting site. It seemed apparent, also, that these artificially established plants lost their fruit about as quickly as the native shrubs. The ability of these shrubs to withstand forces of plant succession toward forest growth is unknown. In short, the value of these plantings was not apparent to the author.

Seeding.—In addition to seeds of shrub lespedeza, two other plants are being distributed extensively by seed for use in field borders. These are both herbaceous and hence are not subjects of nursery practices. Distribution of seed is even more simple than that of seedlings and the preparation of site and planting is similar to normal agricultural operations on the farm. Balanced against these two advantages are the ones of less sure establishment and even more vulnerability to plant succession.

Serecia lespedeza (*Lespedeza cuneata*) is used in Missouri, Virginia, North Carolina, South Carolina, Delaware, Kentucky and Pennsylvania. It is thought of as a plant providing low dense nesting or roosting cover for bobwhite quail and cottontail. Missouri's active program (158,000 pounds of the 200,000 pounds distributed in 1951) envisions its use in the control of erosion in small gullies. Other states are using the plant most frequently in conjunction with shrub lespedeza plantings. Evidence of use by cottontails was common in Pennsylvania and Missouri. It appears that the plant frequently adds a type of cover all too infrequent in agricultural areas and that it has value from this standpoint. It also is obvious that in areas of rapid plant invasion by conifers or other trees maintenance would be necessary.

Partridge pea (*Chaemaecrista fasciculata*) was used in the Alabama and Florida projects where nearly four tons of seed were distributed in 1951. Stands seen in those two states were heavy and appeared to be producing large quantities of seed said to be of value to bobwhite. The maintenance of plantings by disking or burning is practiced on state-owned tracts, but how well it is carried out on private land is unknown.

Several practices designed to establish plants of value to wildlife throughout fields rather than along borders were observed with interest.

Korean lespedeza (*Lespedeza stipulacea*) was outstanding in this respect throughout the Piedmont Region of states from Delaware south and in southern Indiana, Illinois, Missouri and Kentucky. Delaware planted 333 acres of this seed during the 1950-51 season. In Missouri, Korschgen (1952) reports this plant is used widely both for hay and pasture and is the most important (winter) quail food. In these areas Korean lespedeza may well be of prime importance to quail.

Ryegrass seed is distributed by the Pennsylvania project to farmers for use as a fall and winter cover crop in cornfields. Fields seen had additional green cover that was being used by rabbits.

Florida beggarweed (*Meibomia purpurea*) stands in cornfields on private game areas near Thomasville, Georgia, were demonstrated by Komarek. These developed as a result of increasing fertility with heavy potash applications.

At the Coastal Plains Wildlife Experiment Station in Georgia, work is beginning on developing tillage practices favorable to wildlife and yet acceptable to the farmers of the area.

Controlling plant succession.—Several techniques affecting plant succession, other than planting, were being carried out in various states. A practice designed to increase production of food and cover for wildlife is the fencing of areas against livestock. In New York, some 10,000 acres of woodlots were reported fenced as a result of the habitat improvement program in 1951. Here the project provides part of the materials free, and the farmer is expected to complete the fencing. Indiana and Maryland also assist in the fencing of wildlife areas, although on a smaller scale.

Since the response of vegetation to protection from grazing is relatively slow, no real points can be stated at present. On several ten-year-old areas in southern Indiana, the plant succession toward trees had apparently gone so far as to reduce ground cover and food-bearing plants drastically. It would seem that such programs should allow for occasional cutting or grazing to maintain what might be desirable wildlife conditions.

The practices cited above involved advancing plant succession as described by Leopold (1933) Examples of retarding succession so as to maintain desirable wildlife habitat conditions were observed with interest.

The small-marsh program in New York is outstanding. Here, by flooding shallow areas to create dense emergent vegetation, desirable waterfowl, muskrat and winter pheasant cover is being produced in areas where it was almost non-existent. Missouri farm-pond programs have somewhat similar objectives. Some forward-looking policies as to maintenance also will be necessary here.

In Pennsylvania, 65 000 linear feet of woodland borders have been cut by project personnel at an expense of 25 cents a foot or $360.00 an acre. The borders inspected have a profuse growth of weeds and heavy sprouting of the hardwood stumps. Although they appear to be excellent cottontail habitat and pheasant winter cover, no data on the use by wildlife is available. Here the problem of maintenance in the face of sprouts and forest invasion looms large.

New Jersey workers are experimenting with the use of the axe and the saw in retarding growth of hedgerows. Studies of cottontail populations are being carried on simultaneously.

In several southern states, fire is being used on large state-owned tracts to manipulate cover and food. Certain plantations visited in southern Georgia and Florida are also engaged in this practice. Those near Thomasville, Georgia, under the supervision of H. L. Stoddard are outstanding.

Special areas.—The Indiana and Maryland departments both conduct extensive programs of developing special areas on private farms. Examples visited often constituted islands of cover and food in otherwise intensively farmed regions. A major part of the technique is fencing from grazing; but food (shrub lespedeza, woody shrubs, and Korean lespedeza) and cover (conifers, serecia lespedeza and multiflora rose) also are planted. In each state many areas appear to be overplanted, either with more food than the wildlife (which can use the area) might be expected to consume or with conifers which will soon shade out ground cover. Methods of maintaining desirable combinations of herbs, shrubs and trees by grazing, burning or cutting need to be worked out.

The longevity of these areas as units is of special interest, as many of the other practices mentioned above seem transitory. In 1948 Indiana workers reported on an excellent study of 877 prewar leased areas. This analysis shows unsatisfactory conditions on 45 acres (later discontinued) while habitat conditions are rated as good to excellent in 679 areas and poor to fair on 170 areas. Landowner enthusiasm is listed as "indifferent" in 97 cases and "interested" in 680 cases. In summary, about 25 per cent were listed as "poor" or "abandoned" and 10 per cent of the owners were indifferent. The striking part of the survey in this state is that the older areas still are in existence and furnishing some food and cover in intensively farmed country.

Cost estimates can be made for this project. Computing from the 1950-51 budget of $63,000, which was spent on 317 areas totaling 4,249 acres, the unit costs are about $200.00 per area or $12.50 per acre. Based on areas seen, a ten-year survival of areas may be expected. No data on movement of game from these areas are available; so that their significance cannot be evaluated from the standpoint of game production.

INVESTIGATIONS

The types of investigations carried on in relation to the programs seemed to be dual—administrative checks and research. This is not to imply twice too many. In fact, stock-taking and research seemed to be woefully short of what, in the face of the lack of knowledge, is adequate.

Administrative checks.—Data on the efficiency and significance of the projects were found in some instances. The results of these have been cited in the discussion of actual practices. In Florida, South Carolina, North Carolina, Delaware and Kentucky, annual organized sample checks have been conducted on first summer survival of plantings. In Virginia and Missouri, the survival of materials distributed in one summer have been surveyed. Indiana workers made a detailed survey of the fate of special areas after a two- to seven-year period. As the present survey was carried on, Maryland workers interviewed many landowners concerning areas developed on their property, and in New York studies were being instituted through Cornell University. New Jersey workers, through close work with specific areas, are well aware of their progress.

These checks are all of great value. They are primarily directed toward the fate of plantings—existence or disappearance—with little or no estimate of their significance ecologically.

The problems of longevity—not only the plantings but also of their productivity—have not been surveyed in any state except the Indiana special areas. In view of the frequent use of shrubs in areas subject to rapid invasion by forests, this problem seems of paramount importance.

Research projects.—Studies that might be termed research into basic features of the program are few. Greenwell (1952) has reported on "Farm ponds, their utilization by wildlife" in Missouri. In New York a project designed to explore the plant succession in small-marsh projects is well established. A Pennsylvania research program is studying cottontail habitat manipulation in certain areas. Workers in South Carolina, Georgia, and Kentucky are initiating field studies on state-owned areas to test results. The Florida department has two excellent active studies. In several states—Alabama, Virginia, and Missouri—minor projects on portions of the program are carried on by the Cooperative Wildlife Research Units.

Studies being carried on as the projects develop should be especially mentioned. In Delaware the relationship of corn production to field borders has been analyzed quantitatively and significant data applied to the program itself (Caulk, 1951). In Virginia a field biologist is censusing farms with shrub lespedeza borders to test quail reaction to them. In New Jersey cottontail use of managed hedgerows is watched closely and in Florida research on quail populations in areas developed with shrub lespedeza is being carried on. These are striking demonstrations of workers developing field knowledge of their project as they progress.

The activities of the Research Division of the U. S. Fish and Wildlife Service should be mentioned here. At Patuxent, Maryland, wildlife on a developed farm is being contrasted with wildlife on an undeveloped farm. Mr. Walter Rosene is carrying on field work in Alabama and South Carolina on the relation of quail populations to development of shooting-preserve areas with shrub lespedeza.

Edminister and May (1951) have surveyed the survival and food production of shrubs in carefully selected areas of the Northeast.

These projects, many of them very worthy, are undermanned, underfinanced and underequipped compared to the development projects. When it is realized that there are almost *no data* to show that habitat improvement practices, as now carried on, have increased the security threshold of areas for farm game, their scope and size is most inadequate.

DISCUSSION

When analyzing and evaluating wildlife management programs of this type, five questions should be taken up as follows:

1. Are the programs sound as regards basic plant ecology?
2. Are the programs sound as regards wildlife ecology?

3. What is the permanence of the practice?
4. What are the real costs in terms of game produced over a period of years?
5. Are these questions understood and analyzed objectively by the agencies carrying out the programs?

These points seem basic to a lasting program of habitat management. They should be paramount to public relations, ease of administration, political considerations and the beauties of landscaped farms. Where the latter points are used to justify programs, technicians and administrators alike have learned to regret unwise decisions. The present survey uncovered little actual data on these five points but can serve to point out certain major problems in connection with each.

Plant ecology.—These problems are as follows: Forces of plant succession are rapidly working against shrub and herbaceous plantings in many cases. This is particularly true of the shrub lespedeza in the Southeast. Similarly, the maturity of planted conifer stands may mitigate against ground cover on other developed wildlife areas.

The growth of both shrub lespedeza and multiflora rose appears different east and west of the Appalachian mountains. Wildlife managers must avoid the pitfalls of expecting one plant to react the same in different environments.

The concept that wildlife plants can be grown effectively in places unsuited for agriculture also deserves close scrutiny. It is apparent that in many cases poor land is expected to do wonders in producing food and that we are ignoring the fundamental importance of soil fertility in this respect.

Wildlife ecology.—Problems of significance to wildlife itself are equally important. Small stands of a desirable plant scattered here and there may not replace the larger losses of a changing land-use pattern that eliminates the intermixture of various cover types found under more primitive farming. In many cases the values of small plots appear most doubtful.

Does the opposite approach—that of developing food or cover plants in the fields—offer more possibilities? The ryegrass program of Pennsylvania and presence of Korean lespedeza in many states represent attempts in this direction. The work of Komarek, on private lands, to develop growths of Florida beggarweed, is another approach. Such techniques attempt to affect whole fields rather than isolated spots on each farm.

Closely related to this problem is the one created by extensive programs using one technique in wide areas. How often does the practice merely add food or cover to an already existing abundance of one or the other? In one area, every shrub lespedeza border seen was approached through quantities of Korean lespedeza—an excellent winter food for quail. In another area, blackberry and thornapple plants were being torn out and replaced with multiflora rose.

Permanence.—Three major points related to the permanence of the practices are: (1) plant succession, (2) continuance of food production or of quality in cover and (3) the vicissitudes of farming.

Maintenance probably is the answer to these points. Maintenance was observed on state tracts and shooting preserves where cost has little significance. Can we expect the average farmer to maintain wildlife practices? The answer may be yes when we provide him with an incentive. However, present programs are largely ignoring this question of incentive which was so forcibly described by Miller and Powell (1942).

Incentive programs for farm game were almost entirely lacking. The Pennsylvania program exploits the farmers' fear of hunter damage as an incentive to keep private lands open to hunting. In New Jersey several areas are receiving attention by sportsmen's clubs under state guidance with the same incentive as the prime moving factor. Many of the programs, using coniferous plantings, satisfy the farmers' urge for trees by providing them. None of these appeared too effective in actually improving habitat. It is granted no department could envision providing cash to individual farmers. Perhaps, however, it is time to point out to the hunter that he must offer more direct returns to the farmer. This situation already exists in many well-known waterfowl hunting areas.

Real costs.—The question of cost is largely unanswered. The cost of plants per thousand as distributed is fairly well known. The cost of finishing the job by planting and maintenance is unknown. Finally, the cost for each piece of game produced when the end result of survival of the planting and of its use by wildlife is estimated is entirely unknown. Dambach (1952) has indicated costs in Ohio are "somewhat comparable to the fantastic costs sometimes calculated for game-farm raised birds." This may be true in other states.

In many programs a lack of appreciation of these problems is obvious. Even where understanding is evident, the field men have no time to devote to maintenance or research. Where stress is placed on distributing large numbers of plants or where biologists also handle public relations, amassing data for setting seasons, distributing game-farm birds, and similar duties, the field man is busy indeed. He does not have time to check these points. Frank discussion with many technicians indicated a basic uneasiness on this score but a feeling of helplessness in the face of administrative pressures. It is apparent that much planning was from the central office down rather than *vice versa.*

The reporting of large numbers of plants distributed should not be the sole criterion for judging a program. As shown in the discussion of specific practices many other factors are important. Certainly results reported should be based only on successfully established plantings. A listing of the areas where the plants go and an indication of their probable usefulness in alleviating present habitat deficiencies are also desirable. Such reports would, of course, be based on valid samples of the plantings. In short, ecological quality not numerical superiority should be stressed.

It is recognized that a major problem in transferring results of research into management is the development of modes of operation on a large scale. This problem is extremely difficult with farm game because of the many variables—both wildlife and human—involved. However, ignoring these variables for the sake of immediate efficiency also presents basic difficulties.

SUGGESTIONS

This report indicates the need for more careful checks on and analysis of present programs. It appears that, with six years of large programs behind us, the situation calls for comprehensive, detailed, and constructive field analyses along two lines.

Administrative checks.—Three types of surveys to obtain information on present programs are desirable:

1. Systematic annual study of the survival of plantings, of the value of their location by present methods, and of the quality of sites being used by present planning procedures.
2. Detailed checks of older plantings or practices to survey wildlife use during periods when they are thought to be significant, to ascertain longevity of the plantings and to discover the conditions conducive to continued wildlife use of these plantings.
3. Cost analyses of the programs with an evaluation of the real costs in the light of the findings on annual survivals and long-term values as indicated above.

It is believed that these surveys will indicate that, in certain regions, practices need to be modified or dropped and in others new techniques developed. In other areas they may be intensified and expanded with a more certain knowledge that they will contribute to wildlife.

To facilitate the development of these surveys, the best points in use by the states may be cited.

1. North Carolina's 10 per cent annual check based on the use of

county maps which show each farm where plants have been distributed.
2. Kentucky's standards of evaluation, using not only survival but planting patterns as criteria.
3. Delaware's detailed records of planting dates, procedures, and techniques used on each farm.
4. Indiana's permanent records of special areas showing location of plantings and other data.
5. Pennsylvania's cost accounting records of each practice.

Two other techniques, as yet largely untried, seem worthy of consideration. First, analysis, by all classes, of the production of food or cover by plants during the assumed critical period for these functions. Such a system has been used for food production of shrub lespedeza by Walter Rosene of the U. S. Fish and Wildlife Service. Second, a scale of criteria indicating whether or not the practice adds significantly to the area on an ecological basis. For instance, where winter cover is an objective, the amount of winter cover already existing in the vicinity should be analyzed.

Research.—To explore fully the future possibilities of habitat improvement programs, more fundamental studies are needed. Some of these are:

1. Wildlife numbers as affected by weather, population structure, disease and possibly other factors on improved areas.
2. Forces exerted by plant succession against desirable habitat.
3. Ways and means of influencing plant succession by extensive practices rather than by "spot" practices.
4. Techniques for modifying agricultural practices in fields to favor wildlife.
5. Minimum and maximum size as well as pattern of plantings or cuttings most desirable in each agricultural region.

To facilitate a critical approach to these problems the best points of several current state programs may be cited here:

1. Florida's studies of quail population dynamics on improved areas.
2. The experiment station projects begun by Georgia, South Carolina and Kentucky.
3. The use of university personnel for project analyses in New York.

CONCLUSIONS

As a result of these studies, the author has attempted to outline a few basic points of a sound, long-time program of habitat improvement. Some points in this connection are:

1. A program should be based on studies of the ecology of *different agricultural areas* in the state and should attempt to fit practices not only to the agricultural pressures but also to the wildlife ecology of each area.
2. Following this, extensive approach of encouraging use of plants of value, both in agriculture and wildlife, may be thrown into high gear and combined with the intensive approach on special areas where wildlife values are of paramount importance to the landowner.
3. Workers assigned to the different agricultural areas should examine the results of their projects continually in view of changing them to meet demonstrated needs. *Results reported should be on actual areas in which practices have been carried out and which have survived for at least one year.*
4. Research applied to actual practices and broadened to study fundamental problems on the relation of these practices to wildlife should be organized at the state level and coordinated on a regional level.

SUMMARY

The results of extensive observations and discussions between October 1951 and July 1952, concerning farm-game habitat restoration projects in 15 states are presented. Four general types of operational procedures are indicated with notes on problems concerning specific practices such as shrub and tree planting, seeding, controlling plant succession and special areas. In the case of specific practices, questions of initial survival, ecological significance, longevity, and maintenance are stressed. The lack of specific information on these points and on the values of the practices to wildlife is pointed out. Finally, suggestions on types of approach to answers on these problems are made and in a broad way the fundamentals of a more realistic program indicated.

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DISCUSSION

MR. GOODRUM: The majority of habitat improvement programs in the various states have been developed largely since the last World War. With step-up of the Pittman-Robertson work, it seems to me time to evaluate the habitat-improvement work. A good bit of it has been pretty well scattered—not enough on an acreage basis to really get results. Did anyone else have any comment or question on the paper?

MR. VERNE DAVISON (Soil Conservation Service): That is a very fine presentation of the problems that we face, have been faced with for the past ten years, and will be faced with for the next 25. A good bit of the failure that Dr. Marshall has noticed in current problems is because our educational presentation of these problems are, of course, behind our actual field operations. As he says, our research has been woefully lacking. We need a great deal more of it, and particularly in terms of the game on which we make our breedings. He raises one question of whether we are creating enough food, whether there is adequate food. For the most part we are quite sure that we are not wasting time on planting for food because food is terribly short on almost all farm lands three or four years out of five; on some they are short every year. The multiflora rose, I think we should mention also, is not planted so much for cover itself as it is a protective cover for low food plants in a livestock economy. It permits livestock and farm game to come in.

MR. BILL BLACK (Virginia): I would like to ask Dr. Marshall whether he thinks annual grains other than partridge peas have a place in our farm programs in the South.

DR. MARSHALL: I am unable to discuss that except for the partridge pea program. There were, as I understood it, no distribution of annual food plants with Pittman-Robertson funds, and I did stick to Pittman-Robertson programs here.

I saw some of that food planted down there in the Danville country with Mr. Taylor, and it looked to us like they were subject to some of the problems that our other annual plantings were subject to. However, I didn't make any attempt really to see them, as they are not put out with Pittman-Robertson funds, so I will pass on that.

MR. GEORGE DEFREES (Michigan): I would like to commend Dr. Marshall on his very excellent paper. I think it certainly is a study that, as he points out, deserves further study and not general acceptance indiscriminately.

The evaluation of a good many of these projects, and I think Dr. Marshall would agree with me, should not be delayed until after the project is entirely completed and then the survey made. The studies should be made by the wildlife people prior to such things.

DR. MARSHALL: I think that it should be pointed out that there are some areas in the states where attempts are being made to evaluate some of these problems. They were not being made, in general, on the question of the longevity of production of the plants put out or the longevity of their usefulness as cover. That was one of the points which concerned me greatly because we cannot expect plants put out in 1950 to be the same in 1955 or 1960 or 1970. It seems to be there is the place we have really got to go after this thing. I would like to add that one study of interest has been made by Dr. Carl Hunter, and I believe he plans to publish a paper.

MULTIPLE LAND USE: TIMBER, CATTLE, AND BOBWHITE QUAIL

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INTRODUCTION

The pre-eminence of bobwhite quail (*Colinus virginianus*) as a game bird in the South has long been recognized. Bobwhite is a true product of the land: a natural resource of unquestioned value; a human need of high esteem.

Four years ago Goodrum (1949) addressed this Conference and told of declining quail populations in 25 of 39 sampled states. The principal quail states of the South were among those reporting decreased numbers of quail. The decline was attributed chiefly to current land-use practices, such as, clean farming, livestock raising, and dairying, which resulted in a loss of or deterioration of quail habitat.

Bobwhite is usually thought of as farm game; current quail habitat improvement work is aimed largely at agricultural lands. However, fair to good quail populations can be found remote from cultivation on unmanaged southern forests (Stoddard, 1931; Perkins, 1952; Goodrum and Reid, 1952). The longleaf pine (*Pinus palustris*) forest belt which extends from Virginia around the Atlantic and Gulf Coastal Plain to east Texas harbors quail. These wild lands furnish sport for a large number of quail hunters, for there is not any problem in securing hunting privileges. The longleaf pine lands, an area, according to Wahlenberg (1946), of 15 to 20 million acres, are managed non-intensivey, generally, and intensively locally, for the production of timber and cattle. In west-central Louisiana landowners are finding it economically expedient to coordinate timber and cattle production on longleaf pine land (Bond and Campbell, 1951; Kerr, 1952; Cassady, 1949). The same trend is apparent in other parts of the longleaf pine range.

FIRE

Longleaf pine forest land has been subjected to repeated burning over the last three centuries. It is common knowledge that the free-range cattleman of the South burned the woods to rid the ground of dead mantle and thus bring about new and succulent forage for grazing purposes. The grazing study of pine forest ranges in Louisiana by Campbell and Cassady (1951) reports that the chief result of burning is the removal of old dead grass so that cattle can graze solely on new green grass of high nutritive value. Wahlenberg *et al.* (1939) showed that range burned each winter was better in quality and produced greater cattle weight gains than similar unburned range. Campbell and Cassady (1951) suggest the feasibility of obtaining better distribution of cattle on the range by prescribed burning ungrazed or lightly grazed areas each three to five years. Wild and prescribed fire for forage production is still prevalent in southern forests.

The forester also uses fire in managing longleaf pine lands. He prescribes burning for various reasons: to reduce fire hazard, to control brown spot needle disease (*Scirrhia acicola*), to ready the ground for planting or for seed fall in good mast years, and to control brush and scrub oak growth (Hartman, 1949). These types of burning, both promiscuous and prescribed, of longleaf pine ranges influence quail and quail food plants. Stoddard (1931) has pointed out that the indiscriminate use of fire can work to the disadvantage of quail. However, judicious burning in winter can be used to improve quail habitat.

FIRE AND HERBACEOUS QUAIL FOODS

Stoddard's (1931) work in the east Gulf Coastal Plain, where wiregrasses (*Aristida* spp.) and broomsedge (*Andropogon virginicus*) constitute the main forage and ground cover, showed that desirable quail food legumes came in abundantly following winter burning. Similarly Wahlenberg *et al.* (1939) in their study of fire and cattle on longleaf pine lands at McNeil, Mississippi found that legumes were more abundant on annually burned pastures than they were on fire-free areas.

The influence of fire on herbaceous quail foods has been studied over a five-year period in the west Gulf Coastal Plain area where bluestem (*Andropogon* spp.) grasses replace the wiregrasses of the east Gulf Coastal Plain pine lands. From the examination of the food contents of 3,053 quail craws taken from the wild longleaf pine lands of west-central Louisiana, a lists of salient forb food plants was prepared. On the Kisatchie Division of the Kisatchie National Forest, Louisiana, where records of prescribed winter burns were available, field checks were made for the relative abundance of these quail foods in one-, two-, three-, and four-year or older burns. The number of stems of eleven genera of legumes, five genera of spurges, two genera of sedges and the poison oak plant were tallied in square-meter plots on transects across these various-aged grass roughs or burns. The plots were checked at the end of each growing season. In the five-year period, 3,636 plots were examined.

Table 1 summarizes the material. For the legumes and spurges, one- and two-year-old roughs contained the greatest number of stems. Burns three and four years old contained roughly half the number of stems found in one-year-old burns. The sedges had the greatest number of stems on the two-year-old burns, and the fewest stems in the four-year-old burns. Poison oak was most abundant on one-year-old burns. It was slightly less abundant, but uniformly so, in the older roughs. Of all the plants checked, poison oak and tephrosia seemed to be influenced least by the accumulation of heavy grass mantle. Their abundance was more or less uniform in the four categories of

TABLE 1. AVERAGE NUMBER OF QUAIL FOOD PLANT STEMS PER 100 SQUARE METER PLOTS IN VARIOUS AGE BURNS ON LONGLEAF PINE LAND IN WEST-CENTRAL LOUISIANA, 1948-52.

Plants	Average number of stems per 100 square-meter plots			
	1-year burn	2-year burn	3-year burn	4-year burn
Pea family				
Butterfly pea (*Centrosema* spp.)	8.52	17.57	5.48	6.96
Partridge pea (*Chamaecrista* spp.)	42.38	13.68	6.67	6.86
Rattlebox (*Crotolaria* spp.)	1.00	2.00	0.70	2.30
Tickclover (*Desmodium* spp.)	110.95	61.43	22.84	31.44
Clusterpea (*Dioclea multiflora*)	0.30	0	0	0
Milkpea (*Galactia* spp.)	24.73	15.08	19.88	15.02
Common lespedeza (*Lespedeza striata*)	131.35	1.08	0.14	8.95
Bush clover (*Lespedeza* spp.)	9.43	8.86	3.70	5.77
Rhynchosia (*Rhynchosia* spp.)	5.63	5.28	6.82	2.58
Wildbean (*Strophostyles* spp.)	3.80	2.50	2.70	8.30
Pencil flower (*Stylosanthus biflora*)	131.65	49.45	47.92	38.40
Tephrosia (*Tephrosia* spp.)	195.12	195.48	133.23	197.71
Average for legumes	662.17	370.76	248.81	320.09
Spurge family				
Goatweed (*Croton* spp.)	9.13	1.24	0	0
Flowering spurge (*Euphorbia corollata*)	24.88	12.75	11.57	5.07
Treadsoftly (*Jatropha stimulosa*)	.60	1.24	.29	.29
Queen's delight (*Stillingia sylvatica*)	5.93	9.17	5.34	4.47
Noseburn (*Tragia* spp.)	47.56	46.18	22.25	30.24
Average for spurges	88.12	70.60	39.46	40.09
Sedge family				
Beakrush (*Rynchospora* spp.)	18.72	98.60	39.76	33.03
Nutrush (*Scleria* spp.)	34.99	29.23	12.75	11.84
Average for sedges	54.72	127.83	52.52	44.87
Sumac family				
Poison oak (*Toxicodendron quercifolium*)	31.50	21.30	19.58	23.08
Average for all plants	836.52	590.51	360.38	428.15
Percentage comparison	100%	70.5%	43.0%	51.1%

TABLE 2. PROPORTIONS OF GRASSES AND LEGUMES ON PLOTS, BY TREATMENTS, RED DIRT GAME REFUGE, KISATCHIE NATIONAL FOREST, LOUISIANA, 1949-1952

	Ground Cover							
	Common Grasses[1]		Common Lespedeza		Partridge Pea		Tick-clover	
Treatments	1949	1952	1949	1952	1949	1952	1949	1952
	Per cent							
Control	98	90	T[2]	T	T	T	T	T
Ploughed	98	75	T	0.1	T	T	T	T
Annually burned	98	45	T	19.	T	10.	T	4.
Annually burned & fertilized, 4-12-4	98	41	T	14.	T	3.	T	3.
Fertilized, 4-12-4	98	92	T	0.25	T	T	T	T
Fertilized, superphosphate	98	85	T	3.25	T	T	T	0.25

[1]Chiefly broomsedge (*Andropogon virginicus*).
[2]Trace

rough. Considering all quail food plant stems for the various age roughs, the percentages for the one-, two-, three-, and four-year-old burns were respectively 100, 70, 43 and 51. Collectively, there were more herbaceous quail food plant stems in one- and two-year-old grass roughs than there were in three- and four-year-old roughs.

Also, it was noted that these plants were more robust and thrifty in the lighter grass stands. In the older burns they were suppressed and dwarfed; their seed production was not as good as on the plants in the lighter roughs.

To determine more definitely the influence of fire on grass stands and herbaceous quail foods, six treatments were applied to a six-acre experimental block on the Kisatchie National Forest. The treatments for the one-acre plots were as follows: (1) control; (2) ploughing; (3) annual burning; (4) annual burning and fertilizing with 200 pounds of 4-12-4; (5) annual fertilizing with 200 pounds of 4-12-4; (6) annual fertilizing with 200 pounds of superphosphate. At the beginning of the investigation the entire area had a heavy eight-year broomsedge rough. From sample plots, the ground cover was estimated at 98 per cent grass. Although present on the area at one time, legumes occupied only trace proportions in the ground cover.

Table 2 summarizes the data of this burning study. After treatment for three years, grass ground-cover remained heavy on all but the burned plots. It was reduced to 45 per cent on the annually burned plot and 41 per cent on the annually burned and fertilized plot. Common lespedeza, partridge pea, and tickclover came in abundantly on these plots. They composed 33 per cent of the ground cover on the burned plot and 20 per cent on the burned and fertilized plot. These legumes were found in only trace or small proportions in the other treatments. The use of fire on these experimental plots increased the abundance of desirable legumes from trace proportions to substantial numbers.

GRAZING COMPLEMENTS FIRE

Grazing on the open-range longleaf pine belt tends to complement fire in controlling heavy-grass roughs. Open-range grazing has a tendency to be spotty; grazed areas are found intermingled with heavy roughs. Some of the herbaceous quail food plants, such as, goatweed, partridge pea, tickclover, common lespedeza, rhynchosia, pencil flower and noseburn seemed to benefit from moderate grazing, for it kept down the heavy grass foliage which would ordinarily smother out these plants.

According to Campbell and Cassady (1951) grasses and grass-like plants make up about 95 per cent of the average year-long diet of cattle on the open range, and herbs constitute only four per cent of the diet. In addition to tallying the number of quail food plant stems in the various age burns, a record was kept of the number of stems grazed by livestock on the open range and by deer on a cattle-free area in the Red Dirt Game Refuge, Kisatchie National Forest. Table 3 summarizes the data. Cattle stocking was light, about one head per 60 acres, on the areas checked. Partridge pea, tickclover, milkpea,

TABLE 3. QUAIL FOOD SPECIES BROWSED BY CATTLE AND DEER ON 1,514 ONE-METER SQUARE PLOTS ON A LONGLEAF PINE FOREST RANGE IN WEST-CENTRAL LOUISIANA, 1948-49

	Open Range[1]		Cattle-free Area[2]	
Plants	Total Stems	Per cent Browsed	Total Stems	Per cent Browsed
Pea Family				
Butterfly pea (*Centrosema* spp.)	87	0	171	0.6
Partridge pea (*Chamaecrista* spp.)	474	1.0	130	0
Rattlebox (*Crotolaria* spp.)	0	0	0	0
Tickclover (*Desmodium* spp.)	1162	5.3	430	17.4
Clusterpea (*Dioclea multiflora*)	0	0	0	0
Milkpea (*Galactia* spp.)	222	1.3	235	0
Common lespedeza (*Lespedeza striata*)	1568	0	1141	0
Bush clover (*Lespedeza* spp.)	93	3.2	32	0
Rhynchosia (*Rhynchosia* spp.)	48	0	58	0
Wildbean (*Strophostyles* spp.)	0	0	0	0
Pencil flower (*Stylosanthus biflora*)	1548	0	405	0
Tephrosia (*Tephrosia* spp.)	1276	4.6	1632	2.5
Total & per cent for legumes	6478	2.1	4234	2.7
Spurge family				
Goatweed (*Croton* spp.)	120	1.6	23	0
Flowering spurge (*Euphorbia corollata*)	197	10.1	146	3.4
Treadsoftly (*Jatropha stimulosa*)	1	0	11	0
Queen's delight (*Stillingia sylvatica*)	70	0	65	0
Noseburn (*Tragia* spp.)	439	5.6	463	0.1
Total & per cent for spurges	827	5.6	708	0.8
Sumac family				
Poison oak (*Toxicodendron quercifolium*)	235	0	203	0
Grand total & per cent	7962	2.3	5615	2.2

[1]The open range was grazed by cattle, sheep and goats in moderate numbers.
[2]The cattle-free area was on the Red Dirt Game Refuge, Kisatchie National Forest, La. Although the area was cattle-free, it harbored a rapidly growing deer herd; plant utilization on the area was by deer.

bush clover, tephrosia, goatweed, flowering spurge and noseburn showed some utilization by cattle. Common lespedeza, a forage plant of recognized value in the South, occurred on some of the plots, but it escaped use. Even under grazed conditions, however, this plant is capable of seed production; it is a valuable piney-woods quail food. Although the percentage of grazed stems varied with each species of plant checked, the overall percentage of stems grazed was less than three per cent. With the exception of partridge pea and milkpea, which were not consumed, deer utilized the same plants as the livestock on the open range. Here again the utilization was less than three per cent. Under the existing open range stocking rates, livestock did not seriously damage natural occurring quail foods by grazing. Further, the grazing activity kept down heavy grass foliage and thereby complemented the use of fire in maintaining a good ground cover density for quail food plants and for free movement of quail on the ground.

OTHER USES OF FIRE IN QUAIL MANAGEMENT

The careful use of fire is a helpful tool in other phases of woods management of quail. Stoddard (1931) found fire useful in controlling noxious rodents that inhabit heavy-grass roughs, in retarding and knocking back deciduous jungle undergrowths, in serving as an apparent sterilizing agent, and in maintaining the proper ground cover density for free movement of quail on the ground. His study indicated that quail were reluctant to use areas of heavy-grass roughs, and quail populations in such areas were unusually low. He pointed out that, even if seeds were abundantly present in such areas, quail would not be able to utilize them because of the heavy ground mantle.

From the hunters' standpoint, fire and grazing facilitate good dog work. Heavy-grass roughs cut down on the efficiency of the dogs and rapidly tire both dogs and hunters. Light-grass roughs make piney woods hunting more enjoyable to dog and man.

SUMMARY AND CONCLUSIONS

With proper coordination, timber and cattle can be grown together on longleaf pine land in the South without serious conflict; landowners are finding it economically expedient to integrate production of timber and cattle. Quail are a product of this type land. In handling the land for timber and forage production, fire is employed. Fire, judiciously used, can be beneficial in many ways in managing longleaf pine woods for quail. Investigations of the bluestem-longleaf pine range of west-central Louisiana indicate that controlled winter burning every three or four years in alternating or overlapping blocks will help keep naturally occurring herbaceous quail foods abundant.

Annual winter burning of vegetation on small plots where quail food plants are established will help keep them abundant and their seeds readily available for feeding quail. Herbaceous quail food plants in this area are not grazed heavily when ranges are lightly stocked; hence, light to moderate grazing complements fire by keeping down heavy grass foliage that would ordinarily hinder the growth and seed production of these plants. Fire and grazing are useful in maintaining ground cover density in piney woods that allows freedom of movement and easy feeding conditions for quail. The task of coordinating wildlife production with multiple-use management of wild forest lands mentioned by L. F. Watts, former chief of the U. S. Forest Service, in his address to this Conference in 1946, still remains. The dovetailing of prescribed burning for the benefit of quail into the fire program of timber and forage production on multiple-use longleaf pine forest land of the South is a worthy challenge to sportsmen, to sporting goods entrepreneurs, to landowners, both public and private, and to others interested in the production and management of bobwhite quail.

With the stress on clean farming in modern-day agriculture which leaves little room for bobwhite on the farm, it behooves those concerned to find a better place for bobwhite on the multiple-use forest lands, for it is to these lands that the sportsmen will be looking for quail hunting in the future. The forest lands offer an opportunity for bobwhite management with little conflict to timber and cattle production; the hunter has easy access to hunting privileges on such land. To what other upland game bird can the "one-gallus" hunter turn that will reward him for keeping a bird dog in the backyard the year around with the opportuntiy of hanging his hunting coat near the back door for two and a half months of excellent shooting each year?

ACKNOWLEDGMENTS

I wish to express my appreciation and thanks to Phil Goodrum, regional biologist, U. S. Fish and Wildlife Service, for his guidance and assistance in the field studies; to C. J. Perkins, C. E. Harrison and H. C. Beasley, Federal Aid Project 23 D, Louisiana Department of Wildlife and Fisheries, for ploughing the firelanes, supplying the fertilizer, and assisting with the fertilizer application on the experimental plots; and to Guy Cox, forest ranger, U. S. Forest Service, for accomplishing the burning of the experimental plots.

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DISCUSSION

MR. GOODRUM: It seems to me the facts presented by Mr. Reid speak pretty well for themselves. I have felt for some time that we needed some more study on the effect of fire, and Mr. Reid rendered a great service to wildlife conservation when he undertook to do that thing.

Does anyone else have any comment on this paper?

MR. O. EARL FRYE (Florida): I was particularly interested in the comment that Mr. Reid made relative to the effect of grazing. For many years we have felt that grazing was detrimental to the quail in the Southeast. We have been conducting a similar fight on vegetation in South Florida, and it has been fairly well determined that the proper kind of grazing is beneficial rather than harmful to quail in those natural woodlands.

DR. GOODRUM: We are glad to get your report from Florida. I believe the general consensus of professional information in the South, in the immediate past, was that grazing was detrimental to quail. We found that not to be the case.

MR. WALTER ROSENE (Alabama): I think probably that on forested areas with thick stands of woodland, I doubt seriously whether you could have a high population of quail. You might have a few, but I don't think you could have many. When we talk about quail, I think we ought to think of these areas not just as woodland, but maybe as a lot of trees on an area. The paper just previous to this, by Dr. Marshall, recommended that woodland be protected from grazing. There is a little confusion there. Maybe Mr. Reid could clarify that and give us a little better description of the area he worked on down there.

MR. REID: I did most of my work on the Kisatchie Division, Kisatchie National Forest, which is in random stands of longleaf pine, and it is really a woodland area. It is a reserve area of 30,000 acres. There is no farming. Probably the timber stand density would run 1,000 stems to the acre.

MR. ROSENE: What is the quail population per square mile?

MR. REID: For one area I have one for every ten acres. On the open cut-over land it is one to from 12 to 20 acres. Perkins in his master's thesis indicated that.

MR. FRYE: I would like to add a comment to that business about grazing. I am quite sure that in some sections of Florida, particularly in the farming areas of Southwest Florida, indiscriminate grazing is damaging to quail.

I think that the situation boils down to this: that where there is danger of clearing out too much underbrush, which sometimes happens in grazed woodlands. That is bad for quail; but where it assists in carrying out the program such as you have in Kisatchie Forest, and in our higher grazing country of the Southeast, grazing is beneficial. There are two very distinct situations down there.

DR. MARSHALL: Mr. Chairman, may I make two comments with reference to Mr. Rosene's comments. The woodland that I referred to in my report was a part of the local report and was not a part of my study at all. I don't believe I recommended it, but I believe I pointed out how it was being done, and we did not know what would happen as a result.

I would like to refer to Earl Frye's remarks. He said that we had assumed for many years that grazing was detrimental in the Southast. The reason I tried to make a survey in the eastern United States of farm grazing programs was that for many years it had been felt that grazing was detrimental, and I had reason to wonder whether that was correct. That was the whole basis of the habitat reestoration program, and I attempted to find out. The whole thesis of my paper was that we had better quit assuming that and had better get facts so that we can find out whether we are assuming the correct thing in every area, whether we are assuming the correct thing in some areas, or whether we are assuming the correct thing in no areas. It seems to me that the two statements tie up very clearly.

MR. GOODRUM: I believe that is all the time we have. However, I would like to leave this one suggestion with you. I don't think there is any question that quail hunting can be had in forested lands, mostly, of course, the thin leaf stands such as the longleaf pine; but if you take a forest count, it might be extended to other woods, such as hardwood stands.

On farm land, so far, we have been able to lean pretty heavily on the farmer, and, in my opinion, so far the farmer has done very little to benefit the quail population as a whole.

As to the population, I would like to point out we made a census of 2,500 acres at Eglin Air Force Base and we have not made a quail census except for the marginal land. In that census we found about one quail to 5 to 7 acres. That compares favorably. I believe we gave the total result as a minimum of two; that is, under the farming program and grazing program. In other words, after today I think that you are going to pay more and more attention to the quail management on those woodlands that are susceptible to quail management.

FOURTEEN-YEAR GAME HARVEST ON A 1500-ACRE MICHIGAN FARM[1]

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INTRODUCTION

For the past 14 years, from 1939 to 1952, at the Rose Lake Wildlife Experiment Station, the Michigan Department of Conservation has been investigating the effect of sound land use on farm-game populations. In addition to usual techniques, controlled heavy hunting to permit close harvest of the game crop has been a most useful yardstick in measuring game population levels. This is perhaps the longest continuous period extent reporting kill and hunting effect on farmland in this country.

The inter-relation of kill and hunting effort is discussed and two methods of expressing game harvests are compared. Certain general observations on the effects of good land use and heavy hunting on the game harvest now appear warranted, and tentative conclusions are presented.

THE AREA

Location. The study area is the farmland research unit comprising the western half of the Rose Lake Wildlife Experiment Station. Located in Clinton and Shiawassee Counties in a mixed farming area in south central Michigan, it lies only 12 miles from Lansing and environs, with a population in excess of 100,000.

Size and ownership. The total area contributing hunting information utilized in this study involved about 1,925 acres, originally part or all of 20 farms (see Figure 1). However, the average area hunted each year was 1,551 acres, with extremes of 1,225 and 1,815 acres. In 11 years the acreage deviated less than 120 acres from the average. With few exceptions, all the land hunted was state-owned. Early in the period owners of several nearby privately owned farms along the border of the station, and consistently one interior farm, permitted inclusion of their farms in the controlled hunting area of the station. This assured more complete blocking in and made it easier for hunters to observe boundaries. Most of these farms were purchased by the state and added to the station during the 14-year period.

[1]A contribution from Pittman-Robertson Wildlife Restoration Project W-40-R, Michigan Department of Conservation, Game Division, Rose Lake Wildlife Experiment Station. Appreciation is expressed to D. L. Allen, who initiated the study and carried it to the half-way mark; to H. D. Ruhl, for vital administrative direction; and to numerous colleagues at the Rose Lake Wildlife Experiment station who have all assisted in collection of the data.

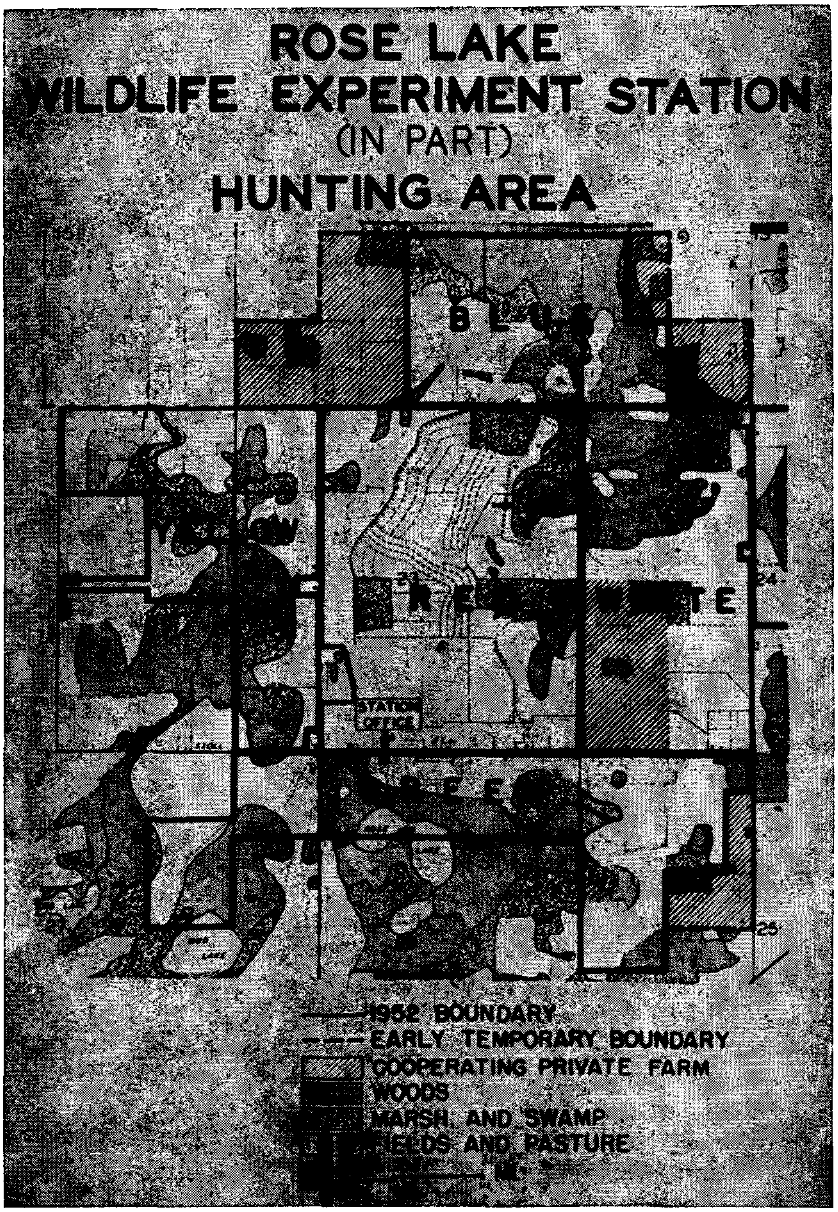

FIGURE 1. MAJOR LAND TYPES AND HUNTER CONTROL UNITS OF THE FARMLAND STUDY AREA OF THE ROSE LAKE WILDLIFE EXPERIMENT STATION

Topography and soils. The land is moderately rolling low moraine and outwash plain. The soils are predominantly Newaygo (or Fox) and Bellefontaine sandy loams of moderate fertility, bordered on north, west and south by extensive undrained areas of Rifle peat and Houghton muck. Smaller areas of loams and loamy sands are intermixed with the sandy loams, resulting in a complex pattern varying considerably in fertility and drainage. No major stream traverses the area.

Land use. Major land use types have occurred, on the average, in about the following composition:

	Acres	Per cent	Acres	Per cent
Upland field and pasture:				
Permanent pasture	400	26		
Corn, Grain, hay	350	23		
Idle or abandoned fields	250	16		
Total			1,000	65
Upland and swamp woodlot			190	12
Brushy swamp, marsh and swale			360	23

Advice of the Cooperative Extension Service of Michigan State College and the U. S. Department of Agriculture, and the U. S. Soil Conservation Service was followed in setting up the farm program. For a considerable period the station functioned as a demonstration soil conservation farm.

Topography and soil indicated that the land was suitable for livestock farming rather than mixed or cash grain farming. Extensive changes in field pattern were required and were completed by 1942. Pastures were relocated on the hilly land and seeded to an alfalfa-brome mixture. A considerable area of the more level land was strip-cropped, requiring removal of over one and one-quarter miles of brushy fencerow. Some sandy and rough land was retired from cultivation. Gullies were plowed in and seeded. Much of the land had been badly mistreated and required a systematic application of lime, fertilizers, and green manure to bring it up to a satisfactory level of production.

The livestock venture sprang from a modest beginning. A beef herd was acquired early and a sheep flock later on. Pastures were being established during the first three years and were generally undergrazed during the next three of four. During the latter part of the period they were utilized nearly to capacity. Pasture renovation has lagged and much originally alfalfa-brome pasture is now principally June grass.

Only enough crops were grown to provide for the livestock. **Rota-**

tions were five to seven years and later four to five years, involving one year of corn, then oats, followed by several years of alfalfa-brome hay. On a few fields a corn, oats, clover rotation could be followed. Relatively more land was in meadow crops during the period of soil rebuilding, and during World War II when manpower was scarce, than during the latter half of the period.

The 14 woodlots ranged from 10 to 25 acres in size, and were mostly overgrazed second growth oak-hickory. A few were elm-maple and mixed hardwood types. None contained much merchantable saw-log timber. Throughout the period they were protected from grazing and fire, and ground cover has recovered remarkably.

GAME MANAGEMENT

Few specific game management measures were installed. An original intent to limit such development to what might occur on an average farm has been followed through. In the main farming area five badly eroded areas aggregating about 15 acres have been planted to woody wildlife food and cover and fenced where necessary. Other plantings are scattered around the fringes on submarginal land. Changes in field boundaries needed to accomplish the changed field pattern resulted in destruction of much brushy fencerow cover between 1939 and 1942. Numerous brush piles for game shelters were constructed in odd areas and along lanes at this period and were added to from time to time. To correct the deficiency in fencerow cover approximately three miles of multiflora rose living fence were planted on crop-pasture boundaries during the last six years. At date of writing most of this is too small to afford game cover.

MANAGEMENT OF HUNTING

Close control of hunters enabled accumulation of a fairly precise record of hunting effort and kill of game. Hunting was allowed by permit only, and daily registration of hunters has been required. In 1939 hunters registered at farm houses on the station, hunted in an assigned area, and reported back at the farm houses to record their bag and time spent hunting. During the remainder of the period every hunter registered at the station headquarters and received a colored hunting permit. He then hunted in a definite area bounded by signs of the same color as his permit. There were four such units in 1939 and 1940 in the farmland study unit, and five thereafter. If a hunter desired to change his hunting area, he turned in his permit and was issued another of a different color.

Upon completion of his hunt he returned his permit, reported game seen and killed, time spent hunting, and other pertinent information, and (except 1939) submitted his game bag for gross external laboratory examination.

Hunters registering at the headquarters have been very cooperative and have not minded spending the time required for reporting. Fewer than 0.1 per cent have failed to report back, and most of the delinquents were later contacted by telephone or mail. A small amount of hunting may have been done around the border of the station by hunters not registering. This was probably balanced by occasional accidental brief excursions of registered hunters into bordering lands outside the station.

Following the usual practice on most Michigan farms no refuges or sanctuaries were set up in the farm study area. A 120-acre sanctuary adjoined the area on the east in 1940-45 but is thought to have had very little if any effect on the study area. No pheasants or rabbits have been restocked on the farmed section. A limited pheasant restocking program, principally of cocks, 1947-49, from one-fourth mile to one mile east of the area, failed to affect pheasant numbers in the study area. Only two released cocks were shot in the farmed area here discussed.

Hunting regulations were the same as those applying generally over the southern third of Michigan, or Zone III. Bag limits were the same throughout the period, or five cottontail rabbits, five fox squirrels, and two ring-necked pheaesants a day. As was traditional in Michigan, hunting seasons for all three species opened on the same day, on October 15 in 13 years, and on October 20 in one year. Rabbits were hunted for 77 days in 13 years, and 103 in one year. Pheasants and squirrels were hunted for 22 days, except 1947-48 and 1949, when 12- and 16-day seasons, respectively, prevailed because of low pheasant numbers. Shooting hours were approximately the same 1939-46. From 1947 on, noon or 10 a.m. opening hours prevailed on the opening day, or the first two days, and in 1949, 10 a.m. through the pheasant season, in an effort to save hens and spread the cock kill over the season.

Because of differences in hunting pressure and type of hunting, the hunting season is divided into two sections in the following discussion. The term "pheasant" season applies to that part of the hunting season when pheasants were the main object of the hunt, but when squirrels and rabbits also could be taken. The term "rabbit" season applies to the remainder of the hunting season, when rabbits only were hunted.

THE GAME HARVEST

During the 14-year period, 18,258 daily permit holders hunted 43,774 hours to kill 4,904 game animals, including 2,345 cottontails,

TABLE 1. ACTUAL HUNTING PRESSURE AND KILL, ROSE LAKE WILDLIFE EXPERIMENT STATION—RED, WHITE, GREEN, YELLOW AND BLUE AREAS, 1939-52

		Permits			Gun-hours			Kill						
								"Pheasant" season						
Year	Acres	"Pheasant" season	"Rabbit" season	Entire season	"Pheasant" season	"Rabbit" season	Entire season	Pheasant	Rabbit	Squirrel	Total	"Rabbit" season rabbit	Total rabbit	Total all game
1939	1,815	714	64	778	1,788[1]	234	2,022[1]	208	102	102	412	27	129	439
1940	1,465	1,040	253	1,293	2,663	629	3,292	152	121	67	340	93	214	433
1941	1,225	1,441	290	1,731	3,327	733	4,060	242	187	63	492	117	304	609
1942	1,465	1,469	288[1]	1,757[1]	3,605	748	4,353	164	196	132	492	142	338	634
1943	1,415	847	123	970	1,917	332	2,249	109	80	66	255	39	119	294
1944	1,525	877	155	1,032	2,215	420	2,635	119	55	36	210	65	120	275
1945	1,475	685	210	895	1,734	574	2,308	50	41	74	165	84	125	249
1946	1,470	878	199	1,077	2,095	509	2,604	47	61	92	200	50	111	250
1947	1,515	916	283	1,199	2,004	663	2,667	41	9	86	136	55	64	191
1948	1,669	1,008	245[1]	1,253[1]	2,365	729[1]	3,094[1]	56	44	40	140	62	106	202
1949	1,669	1,236	346	1,582	2,944	859	3,803	49	109	71	229	111	220	340
1950	1,669	1,099	412	1,511	2,612	967	3,579	50	43	122	215	178	221	393
1951	1,669	1,050	338	1,388	2,343	845	3,188	78	43	100	221	111	154	332
1952	1,669	1,365	427	1,792	2,940	980	3,920	64	35	79	178	85	120	263
Total		14,625	3,633	18,258	34,552	9,222	43,774	1,429	1,128	1,130	3,685	1,219	2,345	4,904

[1]Computed.

1,429 ring-necked pheasants, and 1,130 fox squirrels (Table 1). However, because of varying acreages in the different years, hunting pressure and kill data are presented on the common basis of gun-hours and kill per 100 acres. These are admittedly abstract units. But, the average Michigan farm, according to recent census data, is 105 acres. Hunting pressues and kills cited in this paper may be considered as roughly comparable to those occurring on a farm of average size.

Hunting success has occasionally been suggested as a better indication of game abundance than the game bag. To test this relationship, hunting-success data expressed as kill per 100 gun-hours is also presented. Because of the extremely high hunting pressure exerted on this area, the hunting success figures seem ridiculously low. However, they do seem to express trends in game abundance, and so are included.

HUNTING PRESSURE

The study area was subjected to an average of 204 gun-hours per 100 acres over the 14 years (Figure 2 and Table 2). During the first three years gun pressure mounted from 111 to the astronomical total of 331 gun-hours per 100 acres, a response typical of the opening of new areas to public hunting. Under the impact of World War II, with reduced man power, travel restrictions, and ammunition shortages, coupled with the decline of the pheasant, gun pressure tumbled to 159 and 156 gun-hours per 100 acres in 1943 and 1945. Since that time hunting effort mounted steadily but failed to approach the 1941 peak. Most recent highs were 228 in 1949 and 235 in 1952.

The hunting pressure trends for the entire season were largely determined by heavy gunning during the "pheasant" season. After mounting from 99 to 272 hours per 100 acres during the first three years, the "pheasant" season gunning also dropped rapidly by 1943 to 135 gun-hours per 100 acres, and in 1945 reached a low of 118. It then mounted steadily, with recent highs of 176 in 1949 and 1952.

Hunting pressure during the "rabbit" season showed similar trends. An initial gun pressure of 13 gun-hours per 100 acres mounted to 60 by 1941, and promptly declined to 23 by 1943. A steady rise followed, to recent highs of 58 gun-hours per 100 acres in 1950 and 59 in 1951, or nearly as high as the 1941 peak. "Rabbit" season gun pressure differed markedly from that of the "pheasant" season in this respect.

The distribution of hunting effort between the "pheasant" and "rabbit" season attests eloquently to the drawing power of the ring-necked pheasant as a game animal. Seventy-nine per cent of all hunting occurred during the short "pheasant" season, leaving only 21 per

TABLE 2. GUN PRESSURE, GAME YIELDS, AND HUNTING SUCCESS, ROSE LAKE WILDLIFE EXPERIMENT STATION—RED, WHITE, GREEN, YELLOW, and BLUE AREAS, 1939-52

	Gun pressure (Gun-hours per 100 acres)			Game yield (Kill per 100 acres)							Hunter success (Kill per 100 gun-hours)						
Year	"Pheasant" season	"Rabbit" season	Entire season	"Pheasant" season Pheasant	Rabbit	Squirrel	Total	"Rabbit" season rabbit	Total rabbit	Total all game	"Pheasant" season Pheasant	Rabbit	Squirrel	Total	"Rabbit" season rabbit	Total rabbit	Total all game
1939	99	13	111	11.5	5.6	5.6	22.7	1.5	7.1	24.2	11.6	5.7	5.7	23.0	11.5	6.4	21.7
1940	182	43	225	10.4	8.3	4.6	23.3	6.4	14.7	29.7	5.7	4.5	2.5	12.8	14.8	6.5	13.2
1941	272	60	331	19.8	15.3	5.1	40.1	9.6	24.8	49.6	7.3	5.6	1.9	14.8	16.0	7.5	15.0
1942	246	51	297	11.2	13.4	9.0	33.6	9.7	23.1	43.3	4.5	5.4	3.7	13.6	19.0	7.8	14.6
1943	135	23	150	7.7	5.7	4.7	18.1	2.8	8.4	20.8	5.7	4.2	3.4	13.3	11.7	5.3	13.1
1944	145	28	173	7.8	3.6	2.4	13.8	4.3	7.9	18.1	5.4	2.5	1.6	9.5	15.5	4.6	10.4
1945	118	39	156	3.4	2.8	5.0	11.2	5.7	8.5	16.9	2.9	2.4	4.3	9.5	14.6	5.4	10.8
1946	143	35	177	3.2	4.1	6.3	13.6	3.4	7.5	17.0	2.2	2.9	4.4	9.5	9.8	4.3	9.6
1947	132	44	176	2.7	0.6	5.7	9.0	3.6	4.2	12.6	2.0	0.4	4.3	6.8	8.3	2.4	9.5
1948	142	44	185	3.4	2.6	2.4	8.4	3.7	6.4	12.2	2.4	1.9	1.7	5.9	8.5	3.4	6.5
1949	176	51	228	2.9	6.5	4.3	13.7	6.7	13.2	20.4	1.7	3.7	2.4	7.8	12.9	5.8	8.9
1950	157	58	214	3.0	2.6	7.3	12.8	10.7	13.2	23.5	1.9	1.6	4.7	8.2	18.4	6.2	11.0
1951	140	51	191	4.7	2.6	6.0	13.3	6.7	9.2	19.9	3.3	1.8	4.3	9.4	13.1	4.8	10.4
1952	176	59	235	3.8	2.1	4.7	10.7	5.1	7.2	15.8	2.2	1.2	2.7	6.0	8.7	3.1	6.7
Average	162	43	204	6.8	5.4	5.2	17.4	5.7	11.1	23.1	4.2	3.1	3.4	10.7	13.1	5.3	11.5

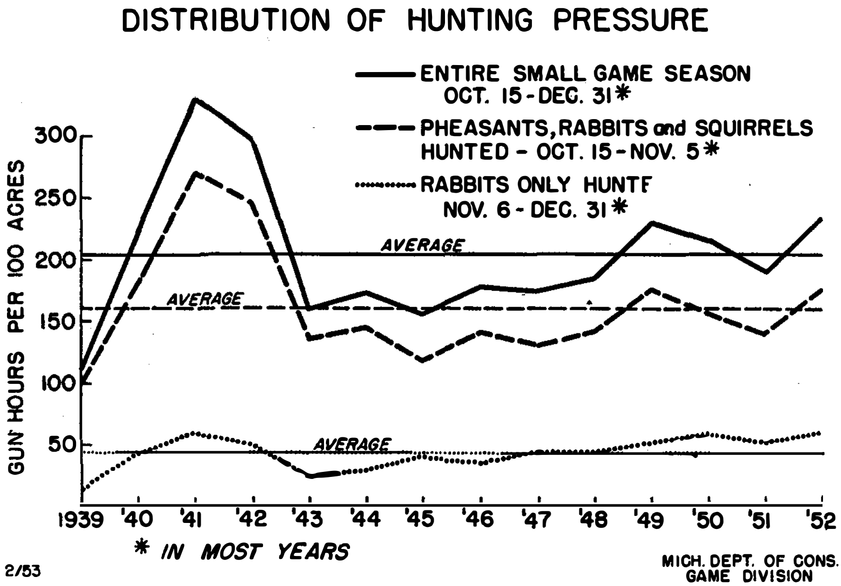

FIGURE 2

cent for the much longer "rabbit" season. The "pheasant" season attracted an average of 161 gun-hours per 100 acres, compared to only 43 hours for the "rabbit" season.

TOTAL GAME BAG

In general the total bag figures for the entire season followed the trends of hunting pressure, but showed wider fluctuations (Figures 2, 3, and Table 2). Mounting rapidly to 49.6 animals per 100 acres in 1941, the bag had dropped sharply by 1943 to 20.8 per 100 acres. However, even though gun pressure mounted slowly but steadily after 1945, the game bag continued to decline, reaching a low of 12.2 per 100 acres in 1948. Moderate recovery brought the bag up to 22.9 in 1950, or almost as high as in 1939, only to meet with further decline during the next two years. The 14-year game bag averaged 23.1 animals per 100 acres.

With the exception of 1939 and 1941-42, years of exceptionally low and high gun pressure respectively, hunting success for all game followed the kill rather closely (Figure 2 and Table 2). Hunting success showed the same deviation from gun pressure trends as did the game bag, including declines in 1945-48 and 1951-52 in the face of gradually increasing gunning. Hunters averaged 11.5 pieces of game per 100 hours of hunting over the entire season. The best year by this

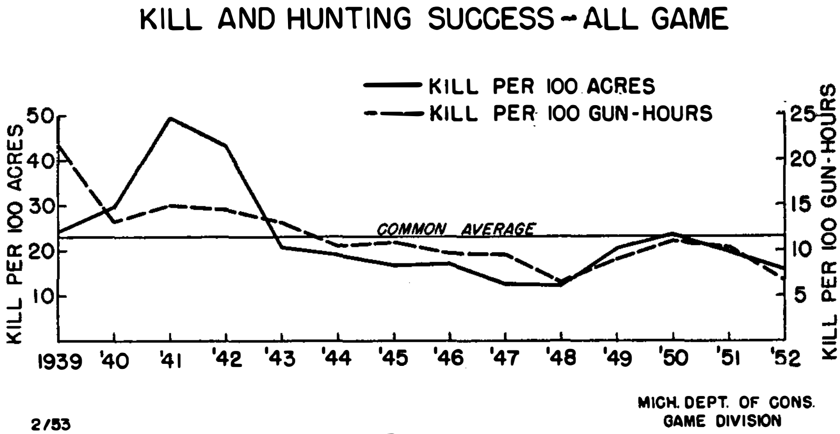

FIGURE 3

measure was 1939, with 21.7 animals killed per 100 gun-hours. The poorest was 1948 with 6.5.

The rabbit was the most important game animal in terms of numbers shot (Figure 4A and Table 2). Ove" the 14 years the bag averaged 48 per cent rabbits, 29 per cent pheasants, and 23 per cent squirrels, with an average kill of 11.1 rabbits, 6.8 pheasants, and 5.2 squirrels per 100 acres. Rabbits topped the bag in 12 of the 14 years. Pheasants were most important in the bag in only one year, 1939, before the rabbit hunting potential of the station became well known. Squirrels predominated in the kill only in one year, 1947, when both rabbit and pheasant numbers were at lowest ebb.

Hunting success also placed the rabbit on top, but not by as distinct a margin (Figure 4B and Table 2). The rabbit was the species most frequently bagged by hunters in nine of the 14 years. The pheasant was the species taken most frequently only in 1939, 1943, and 1944, and the squirrel, only in 1946 and 1947. The average hunting success was 5.3 rabbits, 4.8 pheasants, and 3.4 squirrels per 100 gun-hours.

Variation between years was extreme. The best kill occurred in 1941, with 24.8 rabbits, 19.8 pheasants, and 5.17 squirrels bagged per 100 acres. The poorest, in 1948, consisted of 6.4 rabbits, 3.4 pheasants, and 2.4 squirrels per 100 acres. The best hunting success occurred in 1939, a year of low gun pressure, with 11.6 pheasants, 6.4 rabbits, and 5.7 squirrels bagged per 100 gun-hours. The poorest, in 1948, consisted of 3.1 rabbits, 2.7 squirrels, and 2.2 pheasants per 100 gun-hours.

"Pheasant" season bag. The bag of all game during the "pheasant" season paralleled quite closely the trend followed by hunting effort, and also resembled the pattern for all game during the entire

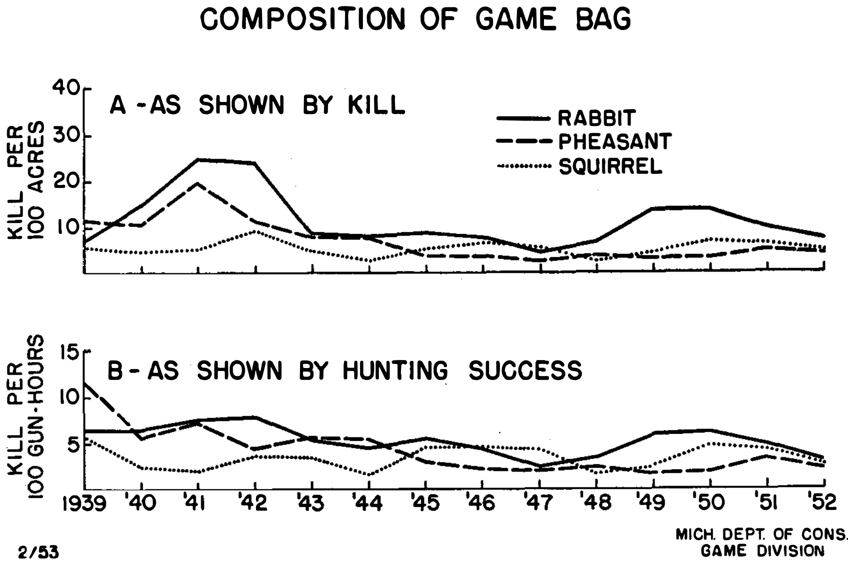

FIGURE 4

hunting season as well (Table 2). The high of 40.1 animals bagged per 100 acres was reached in 1941 and the low of 8.4, in 1948. Partial recovery late in the period reached its high in 1949, with a kill of 13.7 animals per 100 acres.

A similar situation prevailed for hunting success (Table 2). The high of 23 animals bagged per 100 gun-hours occurred in 1939 and the low of 5.9 in 1948. Subsequent recovery to 9.4 pieces of game per 100 gun-hours was attained in 1950, one year later than the comparable figure for the game bag. The average hunting success for the "pheasant" season was 10.7 animals per 100 gun-hours.

As might be expected, the pheasant was most important in the "pheasant" season bag (Table 2). Over the 14 years the kill averaged 39 per cent pheasants, 31 per cent rabbits, and 30 per cent squirrels, with an average bag of 6.8 pheasants, 5.4 rabbits, and 5.2 squirrels per 100 acres. Pheasants and squirrels each topped the bag in six years. Rabbits were most numerous in the bag in only two years, 1942 and 1949, when rabbit populations were high.

Hunting success showed a similar pattern. Pheasants and squirrels were each taken most frequently in six years. Rabbits were bagged most frequently only in 1942 and 1949. The average hunting success was 4.2 pheasants, 3.4 squirrels, and 3.1 rabbits per 100 gun-hours.

Variation in the several years was marked. The best kill occurred in 1941, when 19.8 pheasants, 15.3 rabbits, and 5.1 squirrels per 100 acres were bagged, and the poorest in 1948, with 3.4 pheasants, 2.6 rabbits, and 2.4 squirrels. The best hunting success occurred in 1939, a year of low gunning effort, with 11.6 pheasants, 5.7 rabbits, and 5.7 squirrels bagged per 100 gun-hours. The poorest, in 1948, consisted of 2.4 pheasants, 1.9 rabbits, and 1.7 squirrels.

Rabbit hunting. Over much of the period of study, the rabbit kill appears to follow total gun pressure (Figures 2 and 5A and Table 2). The periods 1945-48 and 1951-52 mark the only appreciable deviation of the rabbit kill trend from that shown by hunting effort. The best years were 1941 and 1942, with 24.8 and 23.1 rabbits bagged per 100 acres. These were also years of heavy gun pressure. The poorest rabbit year was 1947, with a kill of only 4.2 rabbits per 100 acres. The rabbit kill averaged 11.1 per 100 acres for the entire season.

Rabbit hunting success followed the all-season rabbit kill quite closely except in 1939 and 1941 (Figures 2 and 5A and Table 2). These were also irregular years for hunting success for all game. Rabbit hunting success showed the same deviation from gun-pressure trends as did the rabbit kill, including declines of 1945-8 and 1951-52 when gun pressure was increasing. Hunters averaged 5.3 rabbits per 100 gun-hours over the entire season. The best rabbit hunting success was 7.8 rabbits per 100 gun-hours in 1942, and the poorest, 2.4, in 1947.

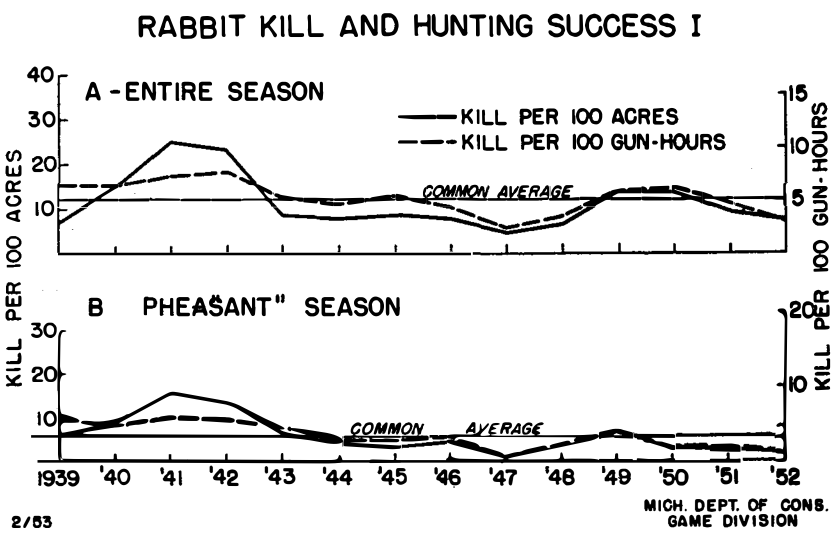

FIGURE 5

The "pheasant" and "rabbit" seasons contributed equally to the entire season rabbit kill, with season bags of 5.4 and 5.7 rabbits per 100 acres respectively. The kill of rabbits during the "pheasant" season only partially followed the trend of hunting pressure for the same period. Both curves showed a similar peak in 1941, but show little resemblance from 1944 on (Figures 2 and 5B and Table 2). As with the entire season kill, the best years were 1941 and 1942, with 15.3 and 13.4 rabbits bagged per 100 acres. The poorest year, again, was 1947, with a bag of only 0.6 rabbits per 100 acres.

The rabbit kill during the "rabbit" season followed the trend of gun pressure for that period, except for 1945-48 and 1951-52 (Figures 2 and 6 and Table 2). Again the best year is 1941, with a bag of 9.6 rabbits per 100 acres, and the poorest, 3.4 in 1946.

"Rabbit" season hunters were about four times as efficient in bagging rabbits as "pheasant" season hunters (Figure 6 and Table 2). Rabbit hunting success when rabbits only could be hunted was 13.1 rabbits per 100 gun-hours, compared to 3.1 when pheasants, rabbits, and squirrels were legal targets. This increased efficiency can be effectively expressed in another way. We have already noted that 21 per cent of all hunting occurred during the "rabbit" season (Figure 2). Yet this 21 per cent of the hunting accounted for 52 per cent of the rabbits killed. This means that the 79 per cent of the hunting during the "pheasant" season bagged only 48 per cent of the rabbits, a vastly less efficient harvest. The main factors producing this condition are hunting on snow and greater use of beagles late in the season, and concentration on one species.

Pheasant hunting. The pheasant bag averaged 6.8 per 100 acres (Figure 7A and Table 2). The best year was 1941, with 19.8 birds

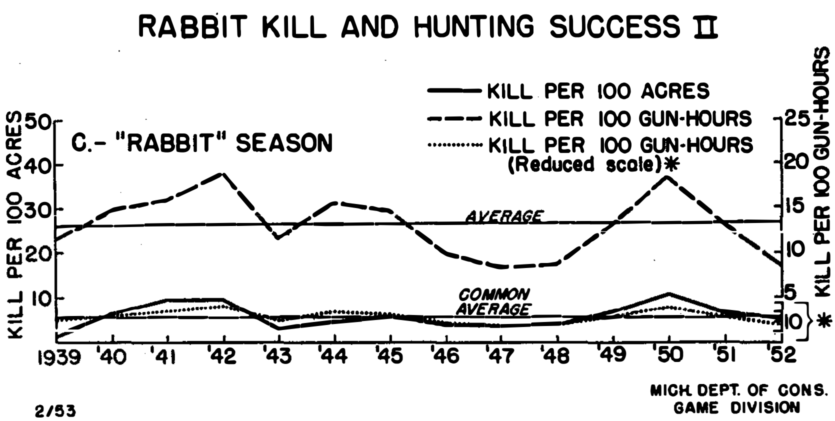

FIGURE 6

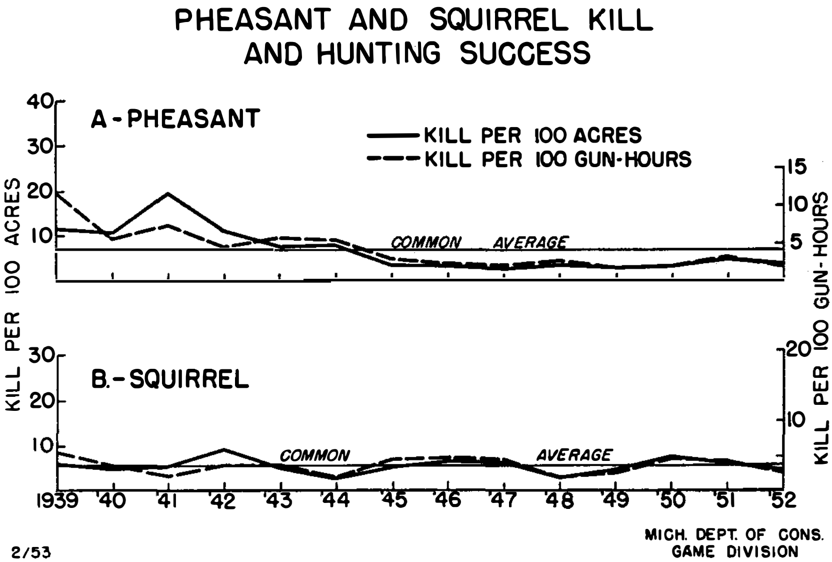

FIGURE 7

killed per 100 acres. The pheasant kill followed gun pressure trends up to 1944, but showed no resemblance thereafter. Mounting sharply from 11.5 to 19.8 in 1941, the kill declined steadily to reach a low in 1945. Subsequent kills ranged around three birds per 100 acres.

Hunting success averaged 4.2 per 100 gun-hours. The highest kill frequency, 11.6 birds per 100 gun-hours, occurred in 1939, a year of low gun pressure. Except for this year hunting success closely follows the trend of the game bag.

Fox squirrel hunting. The fox squirrel kill apparently occurred independently of over-all hunting pressure, and averaged 5.2 per 100 acres (Figure 7B and Table 2). High kills of 9.0, 6.3, and 6.7 squirrels per 100 acres occurred in 1942, 1946, and 1950. This is suggestive of a four-year population cycle.

Hunting success also occurred with little regard for gun pressure. It followed fairly closely the pattern of the trend of the kill, averaging 3.4 squirrels per 100 gun-hours. Hunting success also follows the four-year cyclic tendency of the bag tally. The best year was 1939, with a frequency of 5.7 squirrels per 100 gun-hours, and the worst, 1944, with 1.6 squirrels per 100 gun-hours.

DISCUSSION

At Rose Lake the game bag has been a good indicator of population levels of pheasants, rabbits, and squirrels. Pheasant populations calculated from changes in sex ratio during the hunting season, and rabbit and squirrel populations computed by the Lincoln Index and based on recovery of tagged and untagged animals in the bag, closely follow the trend of the kill of these species. The heavy hunting apparently harvests the game crop so closely that the kill actually reflects the population level.

The close agreement between the trends shown by the game bag and hunting success per unit of effort came somewhat as a surprise. There is little doubt that under heavy hunting such as is experienced at Rose Lake, hunting success accurately reflects trends in populations of pheasants and squirrels, just as does the game bag.

These circumstances suggest that a marked abundance of game may in itself influence gun pressure by making it more profitable for hunters to go afield. Conversely, scarcity of game should discourage hunting. The gun pressure peak of 1941 has been referred to as typical of a new area opened to hunting. It may well have been a result of the abundance of pheasants and rabbits in that year. The lesser peak of 1950 may have resulted from the moderate increase in rabbits in that year.

Our data suggest that the rabbit bag is more responsive to variation in gunning than are the pheasant and squirrel bag. However, in the light of the above, the deviation of the rabbit bag from the trend shown by gun-pressure in 1945-48 and 1951-52 assumes new significance. The pheasant bag and hunting success followed gun pressure until 1944, but not thereafter. The fox squirrel bag and hunting success fluctuated with little regard for over-all gun pressure.

The general agreement of trends of gun pressure, and the game bag and hunting success, during the entire hunting season and the "pheasant" season, is probably due to hunting three species simultaneously. If three game animals, each with a different habitat requirement, are hunted together, it is unlikely that all will have low population levels at the same time. A deficiency in one is likely to be made up by satisfactory abundance of one or both of the other two. This occurred at Rose Lake in 11 of the 14 years. Exceptions were 1947 and 1952, when all species were at a low level, and in 1948, when even a good bag of squirrels failed to compensate for extreme lows in pheasant and rabbit numbers.

The continued decline of the game bag and hunting success, particularly of pheasants and rabbits, in the face of heavy hunting, might lead to false conclusions if other circumstances were not known. The decline of Rose Lake pheasants from 1941 to 1945 was echoed statewide where populations reached an all-time low in 1947. The disturbing fact here is that Rose Lake pheasant numbers reached a lower point, comparatively, and then failed to recover subsequent to 1947. The computed state kill by 1951 reached a level about two thirds the peak kill of the early '40's.

Similarly, the decline of rabbit numbers from 1942 to 1947 occurred all over the state, with the Rose Lake recovery of 1949 and 1950 being matched by a general state increase. However, the state decline was not as drastic as that experienced at Rose Lake.

The continued low in Rose Lake pheasants 1945-52 is not due to excessive shooting of cocks or shooting of hens. An average of about 75 per cent of the cocks were shot regardless of the size of the population or hunting pressure, and the spring sex ratios have consistently been one cock to three or four hens. Constant patrol has failed to detect any evidence of a significant loss of hens due to hunting.

It is possible that the continuous pounding that the pheasants receive tends to drive them off the area. However, in three directions the birds find natural refuge in extensive marshes and swamps, at the borders of the Rose Lake area, where hunters rarely penetrate. Furthermore, these areas are normally used for winter roosting cover by birds which feed regularly in the study area during the day. Harassment by hunters does not seem to be a tenable explanation.

The circumstances suggest a deficiency in the habitat during the later years, making the present farm inferior game range when compared to the early '40's. Establishment of the new pastures and strip fields resulted in the removal of one and one-quarter miles of brushy fencerow, good linear game cover. In the same part of the farm there are now two odd-area, 3-acre game-cover plantings of pines and shrubs and a scattering of brush-pile game shelters, hardly a suitable substitution. Also, the deterioration of some pastures in later years has resulted in a rather barren aspect in many fields in recent falls.

The soil and topography required that most of the cropland be situated in one large unit, and that extensive pastures be the rule. The consolidation of 20 farms into one functional farm unit makes possible extensive changes of this nature which are not feasible on a conventional farm. The land pattern is that of a large livestock farm, deliberately selected as the best land use for this area. It is quite likely that a livestock farm with extensive pastures is inherently a less satisfactory place for game than a cash-grain or mixed-farming enterprise. In sections of Michigan running heavily to livestock farming, pheasants are noticeably less numerous. If pastures are "run out" or overgrazed, as some Rose Lake pastures appear to be, and fencerows are absent, the situation is doubly serious.

The fencerow situation will be corrected in a few years when three miles of young multiflora rose living fence establishes itself. Pasture renovation is being stepped up. If no change for the better occurs when these operations are complete, then increasing suspicion may be redirected at the land use which the topography and soil dictate should be carried on. Perhaps the present low level is the normal level of a livestock farm game population. The corollary to this conclusion is that on such farms extra, special, if not extraordinary game management may be needed to produce game crops at a suitable level, and, in this case, good land use may not necessarily be good game management.

This study possibly offers a glimpse into the future. It applies trends typical of modern agriculture, such as soil conserving and other good land-use practices, and the consolidation of farm holdings. It exerts gun pressure four to five times that occurring on surrounding private farms and so may typify a future condition where there cannot be enough game to go around according to present-day standards. It may well serve as a warning that the prescription for meeting such a situation may have to be drastic and far beyond the scope of our present methods of game management.

CONCLUSIONS

1. Under heavy hunting, both the game bag and hunting success, expressed as kill per time unit, appear to reflect game population trends for pheasants, rabbits, and squirrels.

2. Periods of abundance and scarcity of game may produce corresponding increases and decreases in hunting, rather than the reverse. Under heavy hunting the combined bag of pheasants, rabbits, and squirrels, hunting success when hunting all three together, and hunting pressure, fluctuated uniformly.

4. The rabbit bag seems more responsive to variation in gun pressure than the pheasant, and especially the squirrel bag, but this may be coincidental.

5. Heavy hunting on a soil conservation livestock farm, 1939-52, resulted in a steady decline in game bag and hunting success.

6. The decline has been most marked in pheasants and rabbits and has not affected squirrels.

7. There is a serious question as to whether the heavy hunting is the cause of this decline.

8. Intensification of pasture use and depletion of pastures may be a factor.

9. Fencerows removed in establishing the new field pattern have not been replaced and constitute a definite gap.

10. The inherent limitations of a large livestock farm as game range may be responsible for the reduction.

11. If so, good land use, of itself, is not necessarily good game management.

12. In the farm and hunting conditions of the future, game management far beyond our present concept of the term may well be necessary.

DISCUSSION

MR. GOODRUM: Thank you, Dr. Black, for a very fine paper. Does anyone have any comment on this paper?

DR. EUGENE DUSTMAN (Ohio): I would like to ask Dr. Black if he has been able to collect any information that would explain the peaks in the squirrel kill.

DR. BLACK: We have a rather broken record on such matters, and I am afraid I don't have enough to tie it down at the present time. We are still exploring the matter. I merely pointed out at this time that was a thing that does occur.

MR. REDMOND: I may add that in my squirrel studies I did find that, throughout the state, this kill was concentrated within the mast production areas; in 1948 and 1949 we had a heavy mast production in the northeastern part of the state. The largest kill was in that section, and in 1952 it was in the southern section. I found that these squirrels did shift according to mast production, which is in the fall, and the shift comes a little earlier. It is about the time of the weaning of the summer juveniles.

I had a large shift in my juvenile population, and I credited that to the juveniles of the year due to mast production.

CHAIRMAN ERICKSON: That completes our program for this morning on this Small-Game Session. I want to thank you for your kind attention and participation, these gentlemen who have prepared the papers, and you, Phil, for a job well done.

TECHNICAL SESSIONS

Tuesday Morning—March 10

Chairman: Carl L. Hubbs
Professor, Scripps Institution of Oceanography, LaJolla, California

Discussion Leader: J. L. McHugh
Director, Virginia Fisheries Laboratory, Gloucester Point, Virginia

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COASTAL AND MARINE RESOURCES

RELATIVE ABUNDANCE OF YOUNG FISHES IN VIRGINIA ESTUARIES

William H. Massmann
Virginia Fisheries Laboratory, Gloucester Point, Virginia[1]

Watermen have expressed the opinion that commercial fish production varies considerably from one Virginia estuary to another. Preliminary surveys of the young fishes present in the various rivers have suggested that the relative abundance of young fishes also differs from river to river. The surface trawl (Massmann, Ladd, and McCutcheon, 1952) has been used to obtain quantitative information on the distribution and relative abundance of young fishes in five major Virginia estuaries.

Sampling was done in tidal fresh waters of the Rappahannock River from September 26 to October 1, 1951, and in the James, Chickahominy, Pamunkey, Mattaponi, and Rappahannock Rivers from August 3 to September 25, 1952 (Figure 1). In 11 hours of trawling in 1952, more than 196,000 fishes were captured. Although 27 species were identified, 99 per cent of this catch was composed of seven clupeoid species, namely, the young of glut herring (*Pomolobus aestivalis*), alewife (*P. pseudoharengus*), hickory shad, (*P. mediocris*), American

[1]The author wishes to express his appreciation to Jesse Hobbs and Ernest Ladd for assistance in the field and to Mrs. Doris Lewis for making the illustrations.

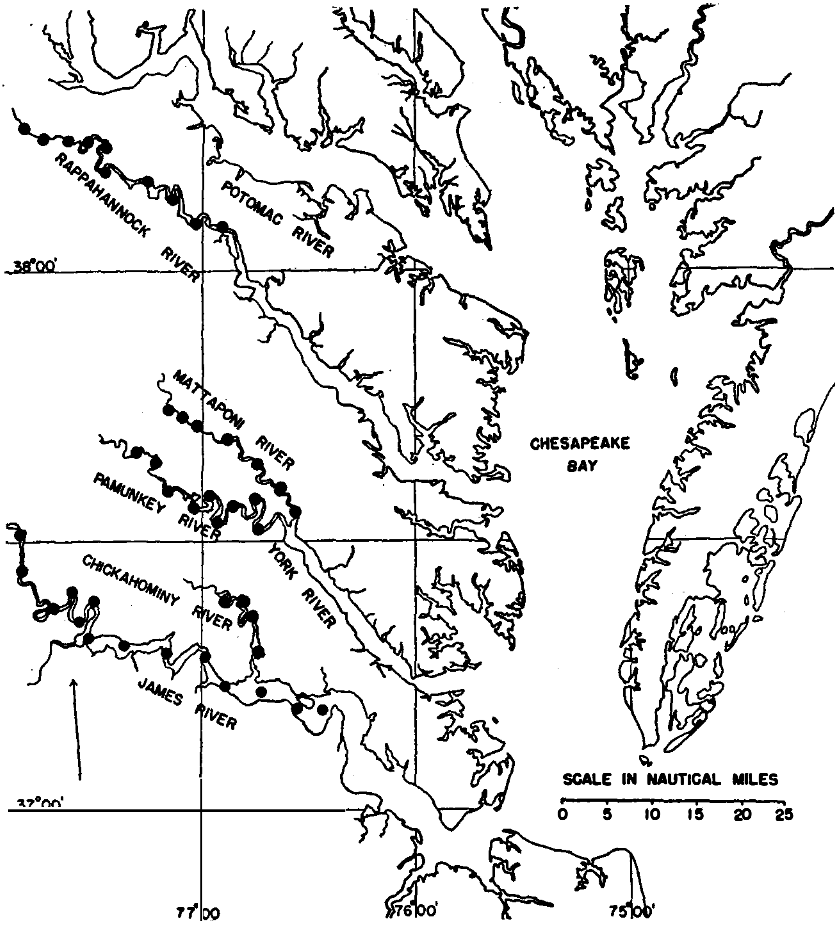

FIGURE 1. CHART SHOWING THE RIVERS COVERED IN THE SURVEY. SAMPLING STATIONS ARE INDICATED BY BLACK CIRCLES.

shad (*Alosa sapidissima*), menhaden (*Brevoortia tyrannus*), gizzard shad (*Dorosoma cepedianum*), and both young and adults of the anchovy (*Anchoa mitchilli*).

Fifteen-minute hauls were made at five-mile intervals in each river, from brackish water to near the head of tide (Figure 1). Because these fishes are not taken in numbers in daytime, hauls were made between sunset and dawn except in the James River. In the James, a freshet had brought down numerous floating trees and logs and increased the turbidity of the water. Light penetration was extremely low, a Secchi disk being visible at greater depths in the other rivers at night than it was in the James during the day. Presumably, conditions in the James River at the time of sampling were similar to those normally encountered at night.

DISTRIBUTION

For comparing the relative abundance of fishes in different sections of all the rivers, each river was divided into six sections of approximately equal length (sections A to F). Since the fresh-water sections of these rivers subject to tidal influence are not the same length,[2] the arbitarary sections of the various rivers differ in length by equivalent ratios. In effect, the shorter rivers were increased in length by appropriate factors to equal the James. Collections made in each section in all the rivers were lumped and an index of abundance based on the average number of fish caught per 15-minute haul was determined for each species.

The relative abundance of fishes in the six sections of all rivers combined is summarized in Table 1. Figure 2 illustrates that glut herring, alewife, American shad, and gizzard shad occurred in greatest abundance within areas B to E, and relatively few were taken in section A or F. The peak of abundance for young shad was located upriver from the region of most intense shad spawning (Massmann, 1952). It appears that young shad tend to move upstream from the major spawning areas during the summer months, or that upstream spawnings are subject to higher rates of survival.

Young menhaden and anchovy were most numerous in the river sec-

[2]The length of the tidal, fresh water portion of each river sampled was: James—55 miles, Rappahannock—50 miles, Pamunkey—40 miles, Mattaponi—35 miles, Chickahominy—30 miles.

TABLE 1. AVERAGE NUMBER OF YOUNG FISHES PER 15-MINUTE SURFACE TRAWL HAUL FROM DIFFERENT SECTIONS OF FIVE VIRGINIA RIVERS. SECTIONS CORRESPOND TO 10-MILE INTERVALS ON THE JAMES RIVER WITH "A" AS THE SECTION JUST ABOVE BRACKISH WATER AND "F" THE SECTION JUST BELOW THE HEAD OF TIDAL WATER.

Species	River Sections					
	A	B	C	D	E	F
Glut herring[1]	81.0	962.0	1,695.0	2,667.0	1,816.0	90.0
Alewife	16.0	370.0	244.0	250.0	591.0	4.0
Hickory shad	11.5	0.0	0.0	0.0	0.0	0.0
American shad	0.1	7.3	17.8	32.8	91.8	2.3
Menhaden	13.3	4.0	16.3	1.6	0.0	0.0
Gizzard shad	0.0	0.5	1.0	12.0	27.0	0.0
Anchovy	565.0	1,060.0	657.0	155.0	1.0	0.0

[1]Over 80 per cent of the glut herring were taken in the Chickahominy River. Therefore, the catch of glut herring from this river has not been included.

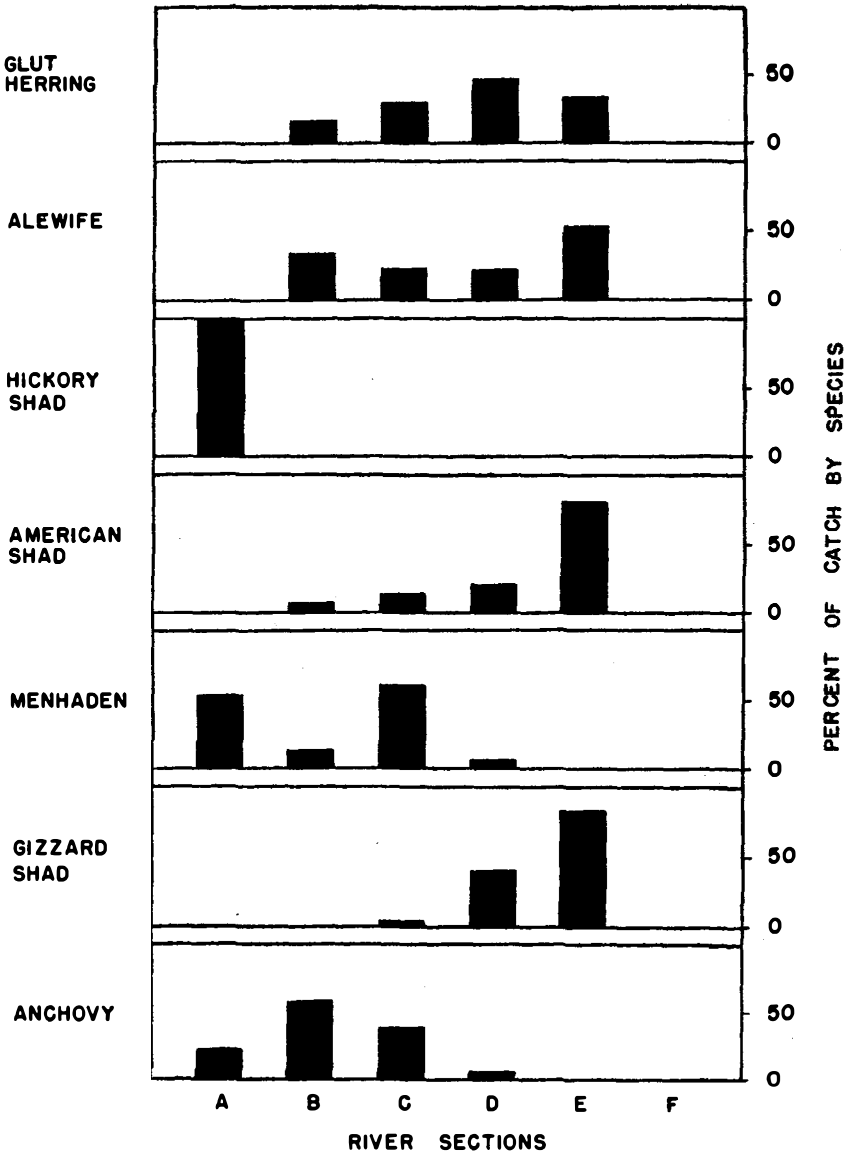

FIGURE 2. THE DISTRIBUTION OF CLUPEOID FISHES IN SURFACE COLLECTIONS FROM SIX DIFFERENT RIVER SECTIONS. SECTIONS IN ALL RIVERS HAVE BEEN MADE COMPARABLE TO A 10-MILE SECTION OF THE JAMES RIVER, SECTION A BEING LOCATED JUST UPRIVER FROM BRACKISH WATER AND SECTION F BEING LOCATED NEAR THE VICINITY OF THE HEAD OF TIDE. SINCE MORE THAN 80 PER CENT OF THE GLUT HERRING WERE CAUGHT IN THE CHICKAMONINY RIVER, DATA ON GLUT HERRING OBTAINED FROM THIS RIVER HAVE NOT BEEN INCLUDED.

tions nearest brackish water. This might be expected, for both are primarily marine species. Hickory shad were captured only in Section A.

RELATIVE ABUNDANCE

The relative abundance of young clupeoids in the five rivers was calculated from the average number taken within each river. For those species found in only a portion of the river, such as menhaden and anchovy, only the samples taken within their range were used in calculating mean abundance. The means, summarized in Table 2, have been plotted as percentage frequencies in Figure 3. Glut herring, abundant in all rivers, were most numerous in the Chickahominy, where 83 per cent of the total number was caught. Alewives, also most abundant in the Chickahominy, were least numerous in the Pamunkey. Hickory shad were taken only in the Pamunkey River. Since this river was sampled first, it is possible that most young hickory shad (adults of which are known to be abundant spring spawners in the Pamunkey, Mattaponi, and Rappahannock Rivers) had already moved downriver when the survey began. The Pamunkey and Mattaponi Rivers, tributaries of the York, produced 77 per cent of the entire catch of American shad. Few shad were obtained in the Chickahominy River.

TABLE 2. AVERAGE NUMBER OF FISHES CAUGHT PER 15-MINUTE SURFACE TRAWL HAUL IN FRESH, TIDAL WATERS OF FIVE VIRGINIA RIVERS AUGUST 18 TO SEPTEMBER 25, 1952. WITH THE EXCEPTION OF THE JAMES RIVER, ALL HAULS WERE MADE BETWEEN SUNSET AND DAWN.

Species and no. of hauls	James	Chickahominy	Pamunkey	Mattaponi	Rappahannock
No. of hauls	14	4	9	7	10
Glut herring	748	30,125	2,448	1,349	1,460
Alewife	152	448	105	309	293
Hickory shad	0	0	46	0	0
American shad	22	2	59	47	7
Menhaden	6	0	14	9	29
Gizzard shad	9	14	0	0	0
Anchovy	558	451	621	167	802

Somewhat more abundant in the Rappahannock than in other rivers, menhaden were present only in small numbers in the Chickahominy during the late summer survey.[3] Gizzard shad were trawled only in the James and Chickahominy although they are known to be present in small numbers in the other rivers. Anchovy were generally abundant in all rivers.

[3]Trawl hauls made in the Chickahominy on April 8 and 9, 1952, averaged 250 small menhaden per 15-minute tow.

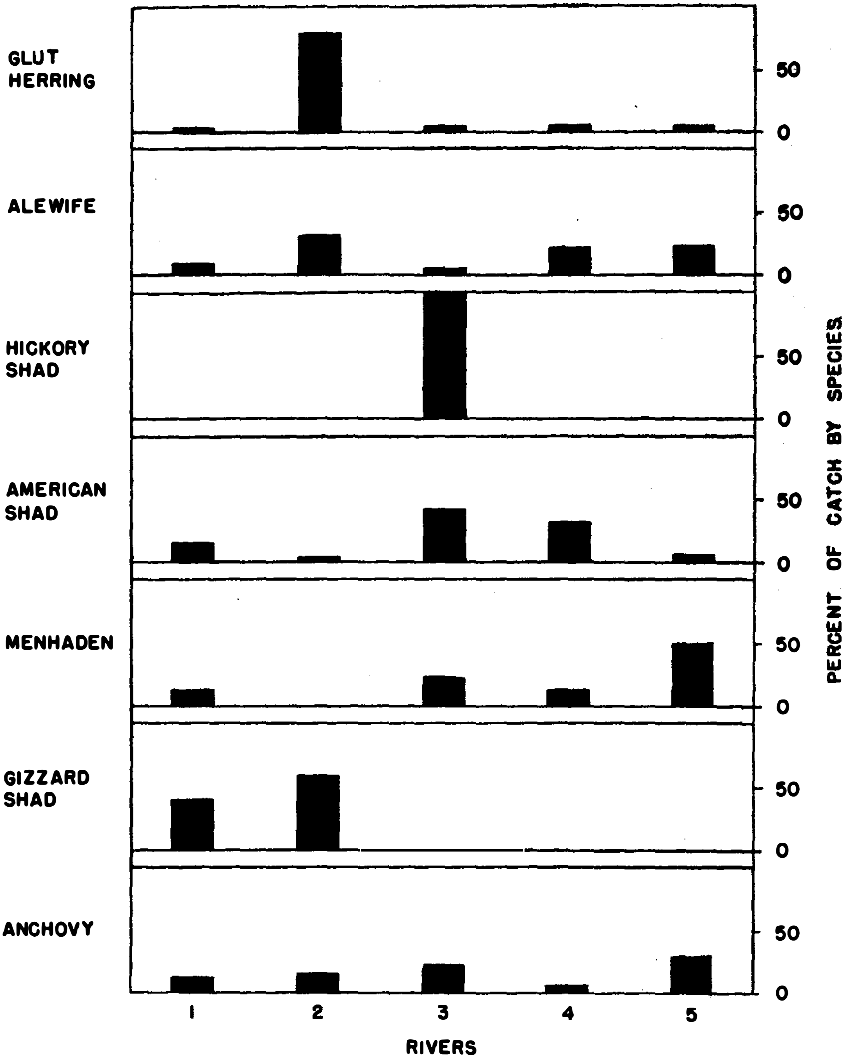

FIGURE 3. RELATIVE ABUNDANCE OF CLUPEOID FISHES IN FRESH TIDAL WATERS OF FIVE VIRGINIA RIVERS. THE DATA ARE BASED ON 15-MINUTE HAULS MADE IN EACH RIVER WITH A SURFACE TRAWL, AT FIVE-MILE INTERVALS FROM BRACKISH WATER TO NEAR THE HEAD OF TIDE, DURING AUGUST AND SEPTEMBER 1952. KEY TO RIVERS: 1—JAMES, 2—CHICKAHOMINY, 3—PAMUNKEY, 4—MATTAPONI, 5—RAPPAHANNOCK.

TABLE 3. AVERAGE NUMBER OF FISHES CAUGHT PER 15-MINUTE SURFACE TRAWL TOW IN THE RAPPAHANNOCK RIVER IN 1951 AND 1952.

Species	Average number of fishes 1951	1952
Glut herring	468	1,460
Alewife	54	293
American shad	4	7
Menhaden	668	29
Anchovy	207	802

ANNUAL VARIATIONS IN ABUNDANCE

Comparative collections for two successive years are available for the Rappahannock River only. In 1951, eight 15-minute night hauls were made at eight approximately equal intervals, spaced from brackish water to the head of tide. These tows are compared with ten 15-minute tows made at five-mile intervals in the same river section from September 23 to 25, 1952 (Table 3). Ratios of abundance in 1952 as compared with 1951 (Figure 4) were 5:1 for alewife, 4:1 for anchovy, about 2:1 for American shad, and 1:28 for menhaden.

SUMMARY AND CONCLUSIONS

Night sampling with a surface trawl during August and September 1952 in fresh, tidal waters of five Virginia rivers has demonstrated that young glut herring, alewife and American shad and gizzard shad are present in greatest abundance well upstream from

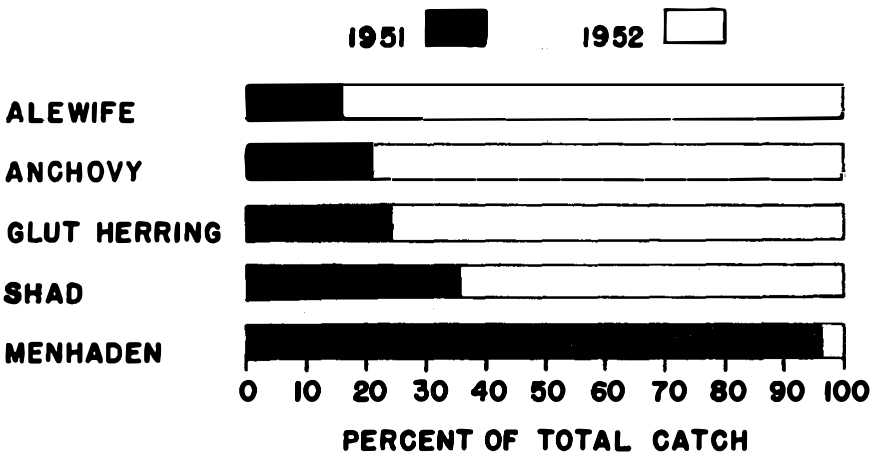

FIGURE 4. RELATIVE ABUNDANCE OF YOUNG CLUPEOID FISHES IN THE RAPPAHANNOCK RIVER IN TWO SUCCESSIVE YEARS. THE DATA WERE BASED ON A SERIES OF NIGHT SURFACE TRAWL TOWS MADE AT STATIONS BETWEEN BRACKISH WATERS AND THE HEAD OF TIDE DURING THE PERIODS SEPTEMBER 25 TO OCTOBER 1, 1951, AND SEPTEMBER 23 TO 25, 1952.

brackish water. It appears that for these species in summer, each river may be considered as an isolated lake with one end situated near salt water and the other near the fall line. Young menhaden and anchovy, on the other hand, although present in these regions in considerable numbers, are not restricted to fresh water. The distribution and abundance of young hickory shad suggests that this species may migrate into salt water earlier than shad, alewife, or glut herring.

The relative abundance of these seven clupeoid fishes varied considerably in the five rivers. Some rivers perhaps are suited particularly to the production of certain species, but none appeared to be most productive of all species.

Variations in the relative abundance of these clupeoid species may be caused by two factors: (a) differences in the numbers of adults spawning in each river and (b) differences in environmental conditions. With the possible exception of the American shad, which is subject to an intensive fishery both in Chesapeake Bay and in each of the rivers, it appears that variations in environmental conditions are most important. A growing body of data is accumulating to indicate that these rivers differ greatly in ecological characteristics.

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DISCUSSION

DR. J. L. McHUGH (Virginia Fisheries Laboratory): I think this problem of trying to estimate future abundance of fisheries by means of survey on the nursery ground has occupied the attention of a good many fishery biologists in this country and other parts of the world to today. We think this particular method is possibly going to be quite useful for Virginia waters. Particularly we feel that this surface trawl is very adaptable to sampling fisheries in rivers where their boundaries are more or less limited, and they cannot get away too easily from the nets.

I know the California State Fisheries Laboratory has done a good bit of work along these lines, particularly with reference to future abundance of the sardine. Perhaps you might have some comments on that, John, as to the values of this method, and your idea as to whether it seems useful in determining future abundance.

MR. JOHN E. FITCH (California Department of Fish and Game): This sampling device has been used mostly in the ocean. It has not been dragged along the bottom. I do not know whether that differs from the device which is used in the Chesapeake area. But I do not really believe they have stopped to determine exactly how important it is. It seems to be the main device for sampling young fish offshore, and for determining the number of eggs in any particular area. It has proven very helpful for determining the size of the parent stock which was spawning in the area; but they believe on the Coast, that they have other means of determining the size of the parent stock. They are tending to go more toward those other means than they are toward the sampling with the tow nets.

DR. MCHUGH: Thank you. Dr. Tiller is here. Perhaps your experience in Maryland might put you in a position to make some comments on this subject.

DR. R. E. TILLER (Maryland State Fisheries Laboratory): Thank you, Larry. I have been watching the progress of this sampling with very, very great interest because, in past years, our sampling for juveniles on this very problem of crop prediction has been very limited. It has been done principally with 100-foot or 200-foot quarter-inch haul-seines, and we have found very striking selectivity of species which are found, as Gillman has indicated, inshore. The Muraenides, the sand perch, the Haemulons, and so forth, are easily taken by beach seine. But we had very, very poor success in working up any prediction methods on populations. I am looking forward to learning a little and getting a little instruction from Bill in developing this method for the Maryland fisheries.

CHAIRMAN HUBBS: I wonder if we could have a brief discussion of the surface trawl.

MR. MASSMANN: This surface trawl is nothing more than a regular trawl, an ordinary net bag which is pulled along through the water, except that we tie one end to one boat, another end to another boat, and pull it along the top of the water, just like pulling a hand seine through the water. There is really nothing to it, except for the fact that we apparently are able to collect fishes which were previously not very available to ordinary methods of collection. Not only that, but it seems to have some use quantitatively. For instance, we can trawl a certain number of acres if we want to. Our hauls are fifteen-minute hauls with, say, seven-tenths of an acre of water; but, just by pulling a little bit longer, we can increase the size of our hauls. It is really a method for straining a lot of water; that is what we are after, rather than just catching fish.

CHAIRMAN HUBBS: What is the dimension?

MR. MASSMANN: The cod end is lined with a one-quarter-inch liner, square bar mesh rather, one-quarter-inch bar; and the net itself is one-inch mesh, the wings and the sides.

However, we assume, perhaps wrongly so, that, as the net is being pulled through the water in this direction, those one-inch holes are not really one inch as the net goes through the water, but much smaller.

CHAIRMAN HUBBS: What is the size of bag and the length of wing?

MR. MASSMANN: The nets are 20 feet from one wing to the other, when we are pulling it as we do with the two boats and the nets extended; it is ten feet deep in the water, down ten feet from the surface.

DR. MCHUGH: I am sure some of you have some questions about the adequacy.

MR. VERNE DAVISON (Soil Conservation Service): Are we getting material evidence of a detrimental effect of side streams, compared with the clear ones, the James against the others?

MR. MASSMANN: Well, I am afraid that, at this point, as far as siltation evidence is concerned, we do have great differences in the turbidity of our streams, but the Chickahominy and Mattaponi are considered clear streams. I cannot, offhand, remember the Secchi-disk ranges; however, the James and Pamunkey Rivers are much more turbid.

However, the curve we get in the number of young fishes or the relative number of young fishes does not seem to coincide. For instance, in the Chickahominy, we get large numbers of one species; however, the Pamunkey, which is one of the most silty streams, gives very large numbers of shad.

There is some evidence that, in one particular river, in the James River, where they have cut through a number of buoys, those particular cut-offs have changed the river enough so that it appears that fishes normally found in rivers are not so prevalent anymore, as far as shad is concerned, since the cut-off has been made. That is one change; but, as far as evidence of turbidity, we just do not have it right now.

MR. ROLAND SMITH (New Jersey): I know you mentioned you had trouble in the James River with logs and so forth; but how much trouble do you have with floating debris clogging up your mesh surface, small stalks or something like that?

MR. MASSMANN: We have had almost no trouble at all with debris in the water. In the James River, it was primarily the big trees; we kept bumping into them, and some of them went right through the nets.

Of course, at night, we could not see them. However, under normal conditions, we had no trouble at all with clogging. After doing some minnow-seine sampling and some bottom trawling, it was a very great pleasure to work with these almost pure cultures which we were able to get.

We did some trawling up in the upper part of the Chesapeake Bay, around Havre de Grace, and an area where there is a considerable amount of *Vallisneria* and other weeds and we did get some weed clogging there.

Also, we stopped when we got to brackish waters, in regard to our sampling. In brackish and salt waters, we have had some trouble with jellyfishes clogging the nets.

DR. HUGH BENNETT: I am sort of a journal fisherman; I use corn for bait. I was wondering if there is any danger of this machine you have there being widely adopted. You catch fish at a rate there which would make it seem that some of us fishermen might want to adopt that method. (Laughter)

MR. MASSMANN: I would feel very flattered if I thought anybody would want to adopt a method like that.

Of course, by law, in Virginia waters, trawling in the bay or the rivers is absolutely verboten; it just cannot be done. Although we get tremendous numbers of small fishes, these are mostly young herring and so forth; they are of absolutely no value. We have cooked them up and eaten them, and they are not much good; I would just as soon as eat my manuscript. (Laughter)

DR. BENNETT: Another small question. Did I understand you to say you caught more shad where you had more silt?

MR. MASSMANN: The river which had the greatest number of young shad is one of the rivers which we consider a more silty river than the others. There are some differences in the silting of some of those rivers, just the over-all differences. Of course, that can change from day to day and from hour to hour. But the Pamunkey River is generally more turbulent than some of the others; however, the Pamunkey River is one of the best shad rivers. At least, so it seems from our sampling.

MR. ROMEO MANSWARDI (Chesapeake Biological Laboratory): Bill, have you noticed that, during the sampling season, during the span of the spawning season of those seven major species, did you find wide fluctuation and relative abundance of the seven major forms during that seasonal sample?

MR. MASSMANN: We really have not much of an idea of the variations in the relative abundance of the adults. We have no method for obtaining catch statistics, which is the only way to obtain information on the abundance of adults. Our general observations are, I consider, almost worthless in that regard.

I do know, however, that, in the Chickahominy River, as far as the herring are concerned, there are tremendous numbers of adult herring as compared with the other rivers during the spawning season. But, other than that, we just do not know.

DR. MCHUGH: I am sorry to chop off this interesting discussion, but our time is running out. Those of you who have any other questions, perhaps, can talk to Mr. Massmann after the meeting. I am sure he would be glad to tell you what he can about this work.

I will turn the meeting back to Dr. Hubbs.

CHAIRMAN HUBBS: I am very happy that we did start out here with some very good and lively discussion. I hope you will continue that through the entire session. You may give us a little headache here, trying to manipulate the time; but I think we will probably gain somewhere along the line. That one took just about the scheduled time for discussion.

(Announcements)

CHAIRMAN HUBBS: The next talk, which I hope also will induce discussion, is by my neighbor, John E. Fitch, of the California Department of Fish and Game, at the California State Fisheries Laboratory on Terminal Island, San Pedro. He will discuss, ''Decline of Yield in Pacific Mackerel,'' one of the lines of research for which he has been responsible on the program of that unit.

THE DECLINE IN YIELD OF PACIFIC MACKEREL

JOHN E. FITCH
California Department of Fish and Game, San Pedro, California

INTRODUCTION

With the attention of the Pacific Coast fishing industry focused on the spectacular failure of the California sardine, a similar decline in the Pacific mackerel fishery has gone almost unnoticed. Nonetheless, for the future success of our Pacific coast fishing industry, serious consideration should be given to the causes of this decline and the proposal of remedial measures.

THE CATCH

From 1916 until the 1927-28 fishing season the total annual catch of Pacific mackerel was under five million pounds. Nearly all of this poundage was caught by hook-and-line fishermen and utilized by the fresh-fish trade. Landings increased to about six and one-half million pounds in the 1927-28 season. The catch increased to 39½ million pounds in 1928-29, the first season of large-scale canning, and in the succeeding season, 1929-30, it rose to what was then an all-time high of 56½ million pounds. A sharp drop in landings during 1930-31 resulted from a poor quality pack which would not sell, and the general economic depression. By 1933-34 new canning methods were being used, the quality of the pack was improving, the economic situation was clearing somewhat, and consumer demand became practically unlimited. With the resultant expansion of canning-plant capacities, purse seiners found the fishing profitable, and by the end of 1935 their landings surpassed those of the lampara boats. The catch increased from around 11 million pounds to over 146 million pounds in just three seasons. This 146 million-pound catch of 1935-36 has never again been attained. In the succeeding 17 seasons, and in spite of increased fishing intensity, the catch has declined almost unchecked to the 20 million pound low of the 1952-53 season.

BIOLOGY

The Pacific mackerel (*Pneumatophorus diego*) is a true mackerel, and like other members of its family, it is a pelagic, schooling fish with erratic migratory habits. The mackerel is not continually abundant at any one locality. The range extends from the Gulf of Alaska southward into the Gulf of California. These fish are not abundant north of Monterey Bay and those occurring south of central Baja Califor-

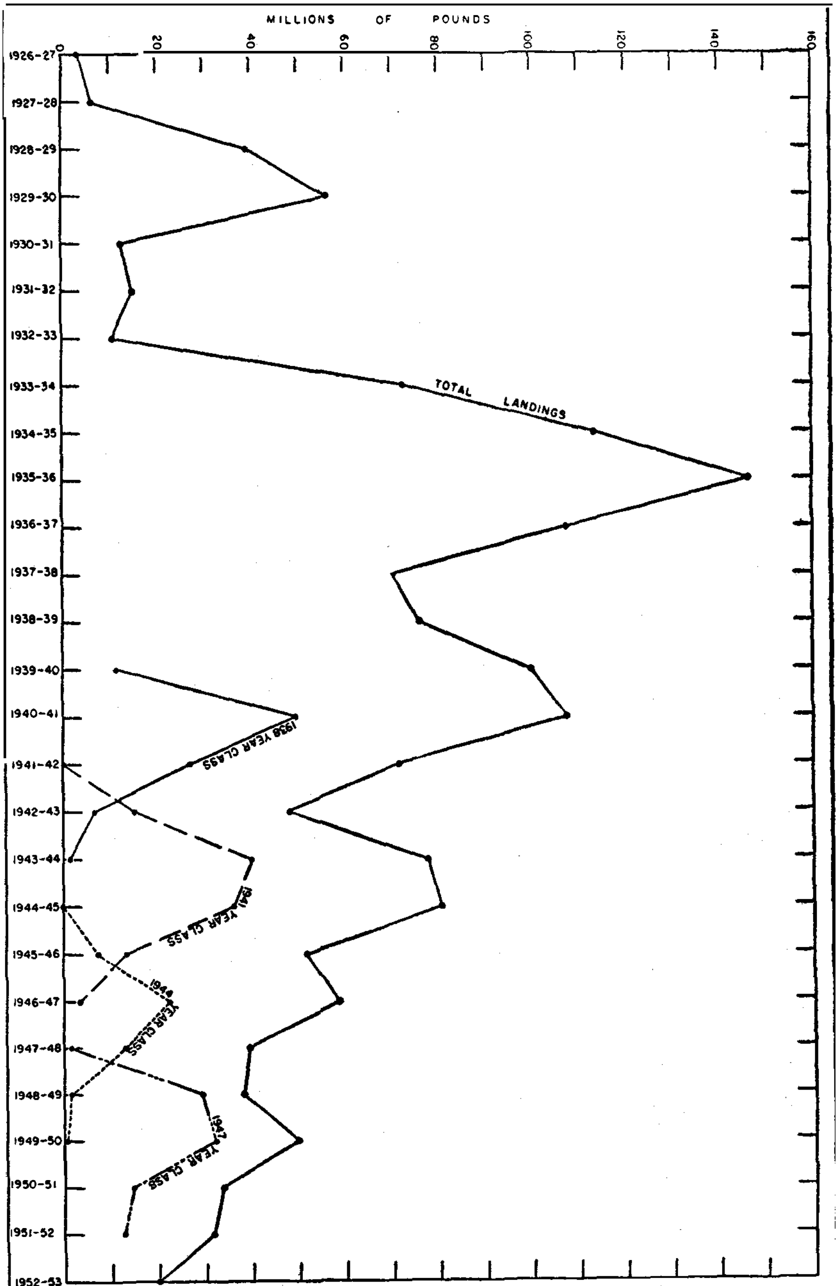

FIGURE 1. TOTAL CATCH OF PACIFIC MACKEREL IN MILLIONS OF POUNDS PER SEASON. CONTRIBUTIONS OF THE 1938, 1941, 1944 AND 1947 INDIVIDUAL YEAR-CLASSES ARE ALSO GIVEN IN MILLIONS OF POUNDS PER SEASON.

nia are probably not important to the California fishery. The fishery is centered in Southern California with the great bulk of the catch delivered at ports in the Los Angeles region (Redondo Beach, San Pedro, Long Beach and Newport Beach). Deliveries to these ports have varied from 83 to 99 per cent of the annual state-wide catch.

The mackerel is a catholic feeder. The usual diet includes anything he can swallow, from fish, squid and tunicates several inches long, down to copepods which are smaller than fleas. Although as a rule mackerel are exceedingly voracious, there are times when they appear decidedly "choosy" about their food or even ignore all offerings entirely.

Of over 21,000 Pacific mackerel for which ages were determined, the oldest was in its twelfth year when caught. Fish over eight years of age, however, are extremely uncommon in the commercial catch. Pacific mackerel attain a length of about nine inches and a weight of a quarter of a pound during their first 12 months. Nearly three years elapse before a mackerel reaches a foot in length and a weight of three-fourths of a pound. A 15-inch fish weighing one and one-half pounds would be around six years of age. The largest Pacific on record was 24.8 inches long and weighed six and one-third pounds; its age was not determined.

Three-fourths of the Pacific mackerel are mature and will spawn when two years (24 to 36 months) of age. A single fish may spawn two or more times each season, though some young fish which have just matured will usually spawn only once. In Southern California spawning begins in late April or early May. Heaviest spawning is from the middle of May to early July, and the season virtually ends in August. Spawning takes place in the open ocean, and the eggs float freely near the surface of the water. The spawning grounds extend from the vicinity of Santa Monica Bay in Southern California south to the tip of Baja California and into the Gulf of California. Eggs are usually found close to shore, most abundantly in water less than 100 fathoms deep, but they have been collected in localities where depths range to 1,000 fathoms. Surface water temperatures at the localities where eggs were most abundant ranged between 62° F. and 69° F. No eggs have been collected in water colder than 57° F. nor warmer than 75° F. Hatching time has been estimated at around three days and the newly hatched larvae are about 3 mm. long.

Mortality rates for Pacific mackerel were determined both through a tagging program and through age work. Tagging results indicated that this was 74 to 78 per cent per year for seasons 1940-41 through 1942-43. From age determinations the mortality rate for fish two years of age and older was calculated for two five-year periods. For the period 1938 to 1942 it was 48 per cent between the second and third year of age, 62 per cent between the third and fourth year and 70 per cent between the fourth and fifth. This means that of one million fish two years old only 59,000 would still remain three years later. The mortality rate in the five-year period 1943 to 1947 was 55, 77, and 80 per cent respectively. During this period only 21,000 out of a million would survive three years. These increasing mortality rates indicate that with present fishing pressures it is not possible to build up a reserve stock of mature spawning mackerel to take care of future needs.

Though mackerel are caught at all ages, the bulk of the catch during any particular season is usually made up of two-year-olds (24 to 36 months). In the 12-season period 1939-40 through 1950-51 all but 13 per cent of the average season's catch was contributed by fish less than four years of age. Nearly 65 per cent of the fish caught were less than three.

Greatest contribution to the fishery by a single year-class was by the fish hatched in 1947. In six seasons, this class alone contributed nearly 150 million fish. Only two other year-classes, 1938 with 126½ million and 1941 with 130 million, furnished more than 100 million fish in a similar period of time. All seven year-classes, 1938 through 1944, supplied better than 45 million fish apiece in six seasons; however, of the year-classes succeeding 1944 only two (1947 and 1948) contributed more than 45 million fish while of the remainder only the 1945 year-class produced more than 10½ million. Preliminary figures

TABLE 1. NUMBER OF FISH LANDED BY YEAR CLASS AT EACH AGE GROUP FROM 0 THROUGH V, 1939-40 THROUGH 1952-53

Year Class	Age Groups 0	I	II	III	IV	V	Totals
1934	....	....	....	....	....	5,340,000	....
1935	....	....	....	....	10,570,000	1,443,000	....
1936	....	....	....	35,130,000	13,551,000	970,000	....
1937	....	....	26,540,000	25,261,000	5,121,000	822,000	....
1938	....	25,200,000	69,322,000	25,661,000	5,271,000	1,082,000	126,536,000[1]
1939	2,960,000	20,793,000	26,454,000	12,698,000	7,133,000	1,616,000	71,654,000
1940	2,313,000	12,507,000	9,204,000	10,156,000	7,712,000	3,328,000	45,220,000
1941	398,000	29,376,000	54,106,000	33,905,000	10,312,000	2,294,000	130,391,000
1942	0	12,462,000	19,047,000	10,259,000	4,661,000	2,019,000	48,448,000
1943	836,000	16,556,000	10,327,000	11,872,000	5,087,000	429,000	45,107,000
1944	0	14,302,000	25,823,000	10,943,000	1,105,000	584,000	52,757,000
1945	556,000	9,330,000	7,980,000	756,000	688,000	72,000	19,382,000
1946	560,000	1,377,000	3,175,000	4,279,000	937,000	218,000	10,546,000
1947	7,181,000	63,330,000	49,255,000	15,826,000	11,127,000	3,037,000	149,756,000
1948	1,061,000	21,818,000	19,228,000	13,871,000	10,083,000	....	66,061,000
1949	136,000	3,854,000	4,428,000	1,294,000	....	....	9,712,000
1950	6,000	1,583,000	563,000	....	....	....	2,152,000
1951	769,000	58,000	....	....	....	....	....
1952	59,000	....	....	....	....	....	....

[1]No information available on the 0 age group of the 1938 year class.

indicate that the 1950, 1951 and 1952 year-classes will not contribute even five million fish each before they are exhausted.

THE FISHERY

The mackerel fishery has passed through four phases: (1) the set-line fishery supplying the fresh-fish trade, (2) the lampara and purse seine fishery, (3) the striker and scoop fishery, and (4) again the purse seine fishery. All but the first of these have contributed materially to the rapid decline in the supply of Pacific mackerel.

When canning of Pacific mackerel commenced in 1928, hook-and-line fishing could not provide fish in bulk and the canners' demands were met initially by lampara boats (small boats which utilize encircling nets that are pulled by hand). The boats used during the early years of mackerel canning were usually less than 50 feet in over-all length and fished within a few hours' cruising radius of their home port. The nets were seldom over 15 fathoms deep and were mostly pulled by hand. Communication from boat to boat was usually limited to shore conversations, and schools of fish had to be located by sight.

By 1934 a majority of the net boats were over 50 feet in length and some were nearly 100 feet. With these larger boats, fishing was conducted farther from port. Through installation of mechanical net pullers, longer and deeper nets were successfully operated and consequently larger loads were handled. This mechanization was also instrumental in the change-over from lamparas to purse seines.

Catches made by the net boats fell off in the years following 1935 and by 1939 the seiners alone were no longer able to meet the demand. The gap was filled by a large fleet of small boats carrying crews of one to three men who employed the methods of striker fishing, and later, "scooping." In striker fishing, mackerel are attracted with ground bait and caught on feathered, barbless hooks attached by a short line to a bamboo pole. The striker fleet played an important part during the early cannery fishery (1928-1929) but was virtually dormant from 1930 to 1933. These boats again became active with the expansion of the fishery after 1933. Striker fishing though not unprofitable did not permit capture of Pacific mackerel in quantity in a short time. In the meantime someone found that mackerel attracted by ground bait could be caught in numbers with a long-handled, wide-mouthed dip-net or brail and this implement, the "scoop," first appeared in the fishery in 1933. The technique evolved over the years and by 1940 was perfected to the extent that scooping at night was supplanting striker fishing by day.

This scoop fleet, numbering in its heyday into the hundreds, has accounted for over half of the total mackerel catch since 1939. In only three seasons since that year has the seine catch exceeded the scoop. However, since World War II many canners have refused to accept scoop fish and by 1950 very few except at Newport Beach were buying scoop-caught mackerel.

In recent years Pacific mackerel have become so scarce that scoop fishermen have been hard put to catch enough for profitable fishing and cannot supply the canners willing to accept their fares. Economic pressure has consequently forced many of these small-boat operators to desert a once lucrative fishery.

Jack mackerel (*Trachurus symmetricus*) and sardines (*Sardinops caerulea*) are species which can be caught profitably only by the purse-seine type boat. Both these species are fished in the same waters as Pacific mackerel and all three species are used for canning. As a result, the purse seiners are actually fishing for one of three species but will substitute either of the other two, if acceptable to the canners. Thus prosecution of the Pacific mackerel by the purse-seine fleet has continued unabated even though fishing for this species alone would no longer be profitable. It is primarily for this reason that the purse-seine catch has exceeded that of the scoop fleet three times in the past six seasons.

Since 1945 installation of depth sounders on nearly all of the boats has made it no longer necessary to have a school of fish "flare" at the surface before it can be located. Installation of radio-telephones has made possible communication with any other boat in the fleet or with shore installations, and when fish are found relatively abundant in a limited area, friends can be contacted immediately and most of the fish caught before they can move to another area.

Fishing with purse seines is normally carried on at night when the phosphorescent wake of a moving school of fish is easily sighted from the bridge or masthead of the boat. Depth sounders made such "sighting" of fish unnecessary during nighttime operations and to a limited extent in the daytime. Quite recently, large-scale daytime fishing became practical by employing an airplane piloted by an experienced fisherman. An experienced pilot-fisherman, flying at elevations of 1,500 to 3,000 feet, can distinguish schools of sardines, anchovies, jack mackerel and Pacific mackerel. Having located the type of fish for which he is searching, the pilot sends a radio call to the skippers of the boats for whom he is working. When a boat arrives under the circling plane the pilot details speed, compass directions, the exact moment to start paying out the net and so on. Seldom in this type of fishing does the crew of the boat see a single fish until the net has been pursed and the school starts milling in it. Such "new" methods in combination with fishing for other species is all that keeps the purse seiners from joining the now defunct scoop fleet.

FUTURE OUTLOOK

The future of the Pacific mackerel in California is not a bright one. The fishery during the past 17 years has been fading rapidly. The reserve spawning stock, fish over four years old, dwindled until in 1950-51 less than three per cent of the Pacific mackerel caught were four years of age and older. More and more is a successful fishing season dependent upon incoming year-classes, and yet only two of the seven year-class spawned since 1944 could be considered of average or better than average abundance. Reserve stocks of older fish are so lacking at present that even when an exceptionally good year-class enters the fishery as in 1947, it alone cannot support the entire industry and the downward trend of the catch continues almost unchecked.

The scoop fleet which in early years fished successfully during January, February and March has for the past several years seldom fished through December, and during the just ended 1952-53 season was almost completely non-existent. Even with the failure of the sardine fishery and the resultant increased fishing pressure of the purse seine fleet on Pacific mackerel there has been no substantial increase in landings.

Closed seasons and minimum size restrictions might help to relieve this situation, but there is little hope that these alone will bring the Pacific mackerel back to its former abundance. The California Department of Fish and Game has recommended an over-all yearly bag limit but to put such a limitation into effect requires the full cooperation of the canners and the fishermen. To date this cooperation has been slow in coming.

DISCUSSION

DR. MCHUGH: Thank you, John, for a very interesting paper.

As Mr. Fitch pointed out, this decline in yield of the Pacific mackerel has been paralleled on the West Coast by a similar, even more dramatic decline in the sardine, which has declined from total landings of something like 800,000 tons in the last 15 years to something like 5,000 tons in the season just past.

On this coast, in the Chesapeake Bay area, we have had similar situations develop. The most striking example, perhaps, is the croaker fishery, which has declined in the last six or eight years from something like 55 million pounds down to just a few thousand pounds.

There is one thing which has always struck me about these curves representing total catch; that is, that in the early part of the fishery, the curve describes roughly something which looks very much like a logistic curve which, when it reaches its peak, then falls over and seems to show a general decline.

It has always seemed to me it is very difficult to get the idea across to the people in the industry that perhaps the big catches of the Pacific, the very peak catches, can never be obtained again in the face of very intense fisheries, simply because, during that time, they were not only taking an amount of fish which more or less balanced the annual production in terms of recruits each year, but also they were crossing off the accumulative stock, and reducing the chances of these fish to reach any great age.

Even if management were successful with these fisheries, as long as the level of fishing intensity remained at its present height, perhaps they could never expect to make the big catches they had in the past.

Perhaps some of you have had considerable experience with marine fisheries, and might like to make some comment.

How about the people in Maryland who have been making catch statistics on the croaker fishery? Do you have any figures available for return on your efforts over the last few years, when the croaker has been apparently declining?

DR. TILLER: I would like to ask one question with regard to the California picture. Our attempt at stabilization of the fishery in Maryland here, scheduled to go into operation in 1941, but delayed by various types of political pressure, seemed to be a sort of logical approach to this business of reducing the total take, without reducing too much the fishing efficiency of the operators in the industry.

We have very limited data indicating a tremendous increase this year, paralleled by an increase in take up to a certain point under the apparent pressure of additional gear.

Do you have any parallel data in your California research which would indicate the feasibility of stabilizing the fishing efforts to stem a depression, to eliminate the necessity of actually establishing closed seasons or bag limits? Is there anything in the California picture which could be used as substantial evidence for the practicability of our approach?

MR. FITCH: There is no question in my mind but what the different kind of gear which is used and the improvements which come in from one year to the next, have contributed substantially to the decline of our fisheries out there.

In the early years, they depended almost entirely upon sighting the schools, and the boats had no means of communicating with their installation or with their friends if they found large concentrations of fish, but with the installation of mechanical fish pullers, they can fish for a bigger area.

The use of ship-to-shore radio is on almost all boats out there now. They can call up a friend and they can fish out an area where the fish has showed up, in almost no time.

They are using depth sounders to locate schools which they no longer need to see near the surface like they used to; they can fish day or night.

Just this past year, in order to increase their catch, they have started successfully using a small plane, which goes up and spots the schools of fish by their milling habits and the color which they show in the water. The fishermen pilot in a plane could tell perfectly well what species it is, and they are able to call the boats up, and can cover tremendous areas that way. What you can do to stop it, I do not know. It would take probably a statutory law, or it might even go deeper than that. Frankly, probably they would tell you you were trying to retard progress or something, and you would probably have a great deal of difficulty. I do do not know just what the solution would be.

DR. MCHUGH: Apparently, John has covered his subject matter so thoroughly that nobody has any questions to ask. Are there any more?

I will turn it over to you, then, Dr. Hubbs, for the next paper.

POTENTIAL TUNA FISHERIES OF THE CENTRAL PACIFIC

JOHN LAURENCE KASK
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The Pacific Ocean is the biggest and deepest ocean in the world. With its Arctic and Antarctic extensions and adjacent seas it comprises in area more than one-half of all ocean areas of the world, and the oceans cover more than two-thirds of the earth. Even the Central Pacific, or, rather, that part of the Central Pacific dealt with here, has an extent somewhat greater than continental United States. It is concerning recent studies in the productivity and potential tuna resources of this part of the Pacific that will be dealt with in this short survey. The studies reported upon have been carried on by the staff of the Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service, with laboratories and operating base at Honolulu, Hawaii.

In 1947 the Congress passed Public Law 329 which authorized the Fish and Wildlife Service "to conduct such fisheries explorations and such necessary related work as oceanographical, biological, technological, statistical, and economic studies to insure maximum development and utilization of the high-seas fishery resources of the Territories and island possessions of the United States in the tropical and subtropical Pacific Ocean and intervening areas as may be consistent with developing and sustaining such fishery resources at maximum levels of production in perpetuity and to provide for the best possible utilization thereof."

Active work at sea under this authorization was started in early 1950. As the authorization was aimed primarily at developing commercial fisheries for the tunas and related oceanic species, the principal objectives as enunciated by the investigators were:

1. To determine what oceanic conditions control the distribution and movements of tunas and tuna-like species.
2. To locate tuna populations in the tropical and subtropical areas.
3. To investigate the abundance and seasonal variations in location of the tuna stocks.
4. To test on a semi-commercial scale possible methods of economically capturing the fish.

The basic and eminently practical approach taken by the investigators to find concentrations of tuna in this great expanse of ocean was to try to find and define ocean areas where tuna could make a living. Tunas eat crustaceans, squid, and small fish. These in turn live on smaller animal plankton. The animal plankton live on smaller plant plankton which in turn grow in great numbers wherever ocean waters rise from considerable depths where they have accumulated rich stores of nutrient salts, such as nitrates and phosphates.

Preliminary oceanographic voyages across the equatorial region just south of the Hawaiian Islands revealed waters rich in nitrates and phosphates in a band varying in position but running roughly parallel to the equator. An area of rich upwelling was found near the equator and a surface convergence a little north of the equator. The original hydrographic sections across these currents were in the vicinity of the Line Islands. Subsequent sections away from island influence showed similar wide bands of nutrient-rich waters, indicating that the upwelling was a consequence of the equatorial current system and was not necessarily associated with land masses.

Wherever nutrient-rich waters were found, there were also rich crops of animal plankton, and where animal plankton occurred in quantity, good catches of tuna could be and were made.

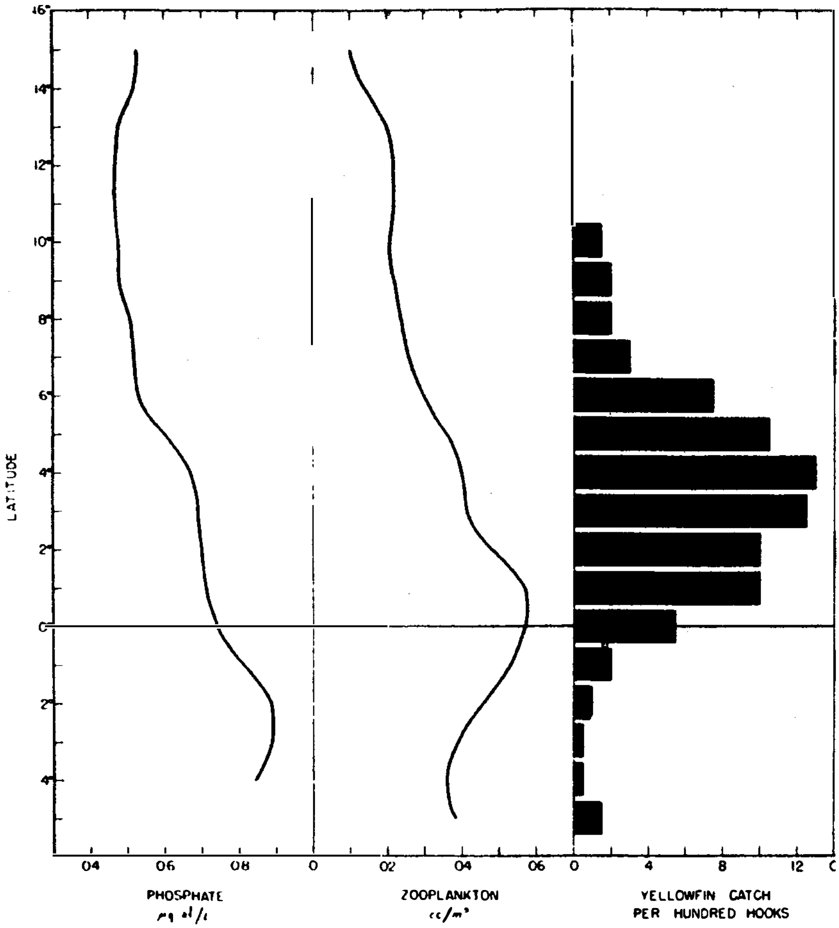
To the present time, combination oceanographic, plankton, and fishing sections have been run across the equatorial current system from approximately 120° West longitude to the international date line, and the band of nutrient-rich waters (and tuna) have been found along all the sections. The accompanying Figure 1 shows the relationship between the catch of yellowfin tuna, the production of zooplankton, and the occurrence of phosphates in relation to latitude during one trip of the research vessel across the equatorial current system.

Thus there has been developed a system of surveying ocean areas by chemical means and translating the findings into productive and nonproductive ocean areas. Green pastures have been segregated from less productive and desert areas in the Central Pacific, and the occurrence and, to a degree, the quantity of subsurface tunas could be predicted.

A further relationship seems to be indicated. The maximum convergence and concentration of nutrients (*i.e.*, tuna) occur with persistent trade winds, while variable winds diffuse and do not especially concentrate the richer waters upwelling from the equator. With southeast trade winds a convergence is expected north of the equator, and with northeast trade winds a convergence is expected south of the equator.

On the average, southeast trade winds prevail at the equator (except from March to May) between 140° West longitude and the Galapagos Islands. Between 140° and 180° West longitude is a transition zone where southeast trade winds predominate but where winds are more variable. The upwelling effect of this wind system is confirmed by sur-

FIGURE 1. THE PRODUCTIVITY OF THE EQUATORIAL REGION.



face temperature data which show the region just north of the equator to be cool in the eastern Pacific and warmer in the western Pacific. From these facts the scientists theorize that tuna will be more concentrated along the equator between 180° and the Galapagos Islands than in the western Pacific, and that June to February will be a better fishing season than March to May.

At the present time the principal tuna fisheries of the world are at the two extremities of the equatorial Pacific—by American fishermen off Central and South America and by the Japanese in the western Pacific. These two fisheries reap the greatest cash crop of fish taken from any ocean. The principal catches made by both the Americans and Japanese are of yellowfin tuna taken from surface schools attracted by live bait. The Japanese have, however, in recent years sent out large mothership expeditions for tuna into waters of the western Pacific surrounding the U. S. Trust Territories of the Pacific. On these expeditions the longline method of catching tuna, developed by the Japanese, has been used. This method involves laying of miles of line with shorter attached lines carrying baited hooks. In nine mothership expeditions in 1950 and 1951 the Japanese caught 34 million pounds of tuna in this way. This method of fishing has the advantage of being independent of live bait, which in many areas is difficult to obtain, and also it catches fish which occur below the surface. The number of tuna caught per 100 such baited hooks has been used by the Japanese and by American research men to give some idea of the relative abundance of tunas in the various parts of this Pacific area where either commercial or scientific fishing has been done.

During the nine mothership expeditions referred to above, the Japanese caught 2.4 tuna of all kinds per 100 hooks in the western Pacific. During the season of the southeast trade winds, the Government research vessels caught 7.9 fish per 100 hooks, or three and one-half times as many in the Central Pacific between 150° and 160° West longitude. Similar comparisons cannot be made in the eastern Pacific where American fishermen fish, as the longline method of fishing has not yet been used there, but there is every indication that fishing for subsurface tunas should be good.

The Pacific extends for nearly 10,000 miles along the equator from the Americas to Asia. Only a relatively small area on each end is presently actively fished for tunas. There is a growing body of convincing evidence that there are substantial tuna stocks right across this 10,000 miles of Pacific. Commercial fishing is only beginning to move into this great and distant area, so that conclusive evidence of the sizes of the stocks from actual catches is not yet at hand, but each new piece of evidence as it is developed further confirms that there are highly productive areas in the Central Pacific which may, as fishing techniques improve and the need for food increases, become the scene of a great fishery.

DISCUSSION

DR. MCHUGH: Jack, in your opening remarks, you completely stole my thunder; I was also going to make reference to Dr. Harrar's talk relating things he said to things you said. I am a bit at loss for words right now.

I think this work in the Central Pacific has been very interesting, because it is one of the first examples I know of in this country, at least, of the direct application of oceanographic research to the benefit of the fishing industry. We hope this is just a beginning, and that the wedding between oceanography on one hand and the commercial fisheries on the other is consummated and brought closer together.

I see Ed Dahlgren sitting way at the back of the room there. I do not know whether it is diplomatic to ask you to comment on Dr. Kask's paper, but perhaps you would like to say a few words.

MR. ED. DAHLGREN: That is hitting sort of below the belt, but I think Dr. Collier's address which is to follow, on the Gulf of Mexico, will throw a bit of light on what Dr. Kask said. I think I have nothing further to say.

DR. MCHUGH: Thank you, Ed. I did put you on the spot a bit, I think.

CHAIRMAN HUBBS: I might make just one remark. It was interesting to note that the Japanese fishermen, whom we rate very highly for their ability to remove organic matter or products from the sea, are very skillful at that. It was very interesting to note Dr. Kask's remarking that our scientists out there at POFI had been doing a better job in terms of the number of fish caught per hundred hooks than the Japanese.

However, that is probably not a matter of differential skill. Some of the most recent works from POFI which I heard a few days ago from Honolulu has been in the same area where Japanese fishermen worked, and our scientific fishermen there made catches quite comparable to those of the Japanese.

So there again we have further evidence that the catch of the tuna is definitely related to the organic productivity which is, in turn, related to the upwelling of nutrient material in that particular part of the equatorial current system.

DR. MCHUGH: Are there any more comments no Dr. Kask's paper?

DR. HUGH BENNETT: I just wanted to ask a small question there. With reference to these phosphorus- and nitrogen-rich equatorial waters, I believe you indicated that there is no relation to land mass; but I was wondering if this upwelling you speak of might bring up ocean-bottom material which has some relation to this richness in deposits of nitrogen?

MR. KASK: Do you have reference there, sir, to living organisms?

DR. BENNETT: No, with reference to bringing up sediments from the bottom of the ocean in relation to the richness of these equatorial waters in phosphorus and nitrogen. Could there be any relation there?

MR. KASK: That general area is extremely deep; but what actually happens is, as you undoubtedly know, the nutrient-rich waters have a tendency to sink to the bottom, and the upwelling of these rich waters is usually associated with current system when they approach the land, or when there are prevailing winds over the land, which remove the surface current and bring up some of these rich waters to the surface.

It seems that, in the equatorial current system, where the prevailing winds are the trade winds which blow in the same direction and at a fairly constant velocity for long seasons or periods of the year, this upwelling, the removal of the surface current and bringing up of rich nutrients below is almost a constant process. The winds have been very carefully established so that our scientists can almost predict as to when the fishing will be available in that area, by studying the wind charts which are made quite frequently and periodically.

It is a consequence of the current system which, in turn, is a consequence of the prevailing winds.

CHAIRMAN HUBBS: Primarily the mid-water which brought it up, and not the actual bottom water, not the bottom material. There is much upwelling near the shore and even over the very deep submerged banks, even over the sea mouths, there may be an increase in the nutrients.

DR. MCHUGH: Actually this water, perhaps, comes up from a matter of only a few hundred meters, just below the zone in which photosynthesis takes place.

Are there any more questions on this paper? Any more comments?

I will hand the floor back to you again, Dr. Hubbs.

CHAIRMAN HUBBS: Next is a paper which quite a number of us have been wanting to hear, because we have heard rumors of the work and are very much interested in getting some of the details. It is very fascinating and probably important development in fisheries.

THE SIGNIFICANCE OF ORGANIC COMPOUNDS IN SEA WATER

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INTRODUCTION

Since the time of Pütter (1909) much effort has been expended on the problem of the direct utilization of dissolved organic compounds by marine organisms. Most of the consideration has been on the basis of total carbon in conjunction with such criteria as over-all growth and respiratory equivalents. As recently as last year Jørgenson (1952) stated: "It is not finally settled whether filter feeders obtain their food from the particulate fraction only, or whether they are also able to utilize the so-called dissolved organic matter in the sea." The use of the term "dissolved" is to some extent ambiguous and in the sense used here should be considered to include colloidal organic materials. Fox *et al.* (1952) and Goldberg *et al.* (1952) have developed methods for collecting these materials (not necessarily those which are dissolved in the strict sense) by a special filtration technique. They introduced the term *leptopel* to include the finely divided particulate materials and organic dispersions. Their quantitative results were given in terms of total carbon.

A somewhat different approach has been taken by Wilson (1951, 1952) who adapted a type of bio-assay to the demonstration of the biological differences between waters of different origins. Cooper (1951) conducted a brief chemical study of the areas involved and found that the water which was most favorable to the development of the invertebrate larvae used as test organisms by Wilson came from the areas showing a comparatively high rate of phosphate regeneration. It was not claimed that the phosphate was the critical factor, but simply that the phosphate regeneration indicated a level of biological activity at which growth promoting substances might have been formed.

Fox (1950) gave a general review of the metabolism of detritus as food for detritus feeders and discussed briefly the lipochromes to be found in the sediments. Kalle (1949) reported certain yellow substances which he isolated from the sea water and which fluoresce under ultraviolet light.

In 1948 my co-workers and I (Collier *et al.,* 1950) began an investigation of this problem along an entirely different line. This approach was based on the study of the existence of specific organic compounds in natural sea waters and their effects on marine organisms. We started out by testing for tyrosine-tryptophane and carbohydrates. It soon developed that there were susbtances present which influenced the rate of filtration of the oysters and which responded to the carbohydrate test used (N-ethyl-carbazol). This was encouraging, for it meant that we had found a biologically active compound (or group of compounds) to which an organism would respond quantitatively.

These findings bring into sharp focus for the marine biologist Lucas' (1949) treatment of external metabolites, or ectocrines, as he called them.

PROGRESS IN WORK ON SPECIFIC COMPOUNDS FOUND IN SEA WATER

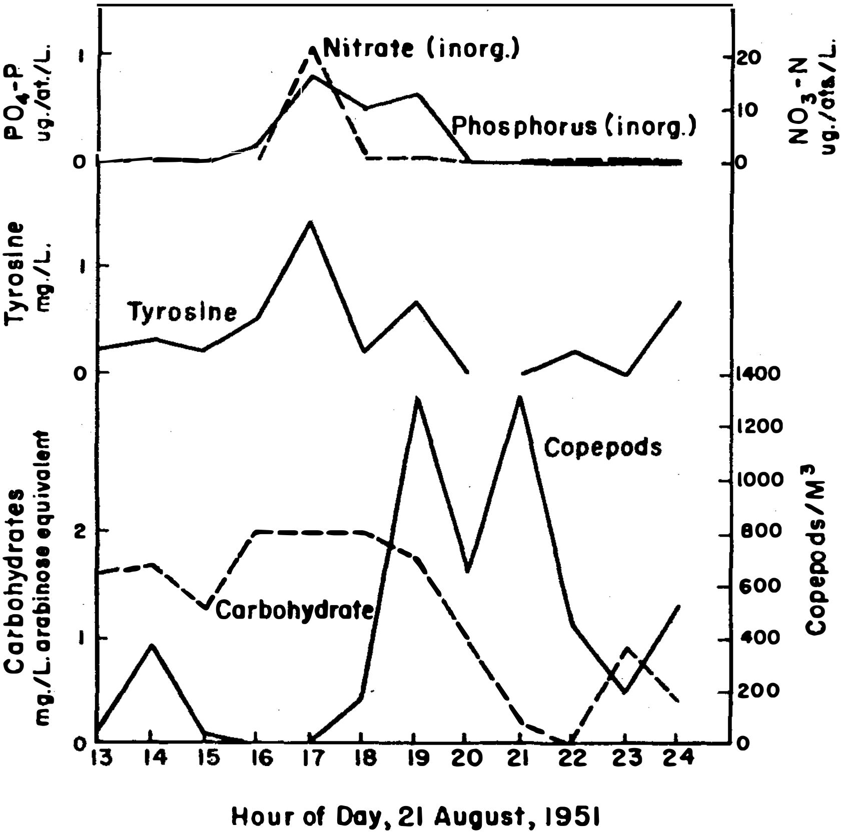
In general, we would expect all sorts of compounds to be present as degradation products of dead and dying animals and plants. Also, we would expect some quantity of excretory products, as well as diffusable metabolites which passively escape the more permeable boundaries of plant and animal masses. Some could result from extrinsic bacterial activity and many others from an intrinsic enzymatic system. The general scheme for this complex set of factors is graphically figured by Fox (*loc. cit.*).

Neritic waters can be viewed much as the mammalian physiologist would view blood: as a transport system charged with living cells and agglomerates of proteinaceous and carbohydrate complexes, as well as dissolved gases. There is good reason for the marine biologist to approach the problems from the point of view of blood chemistry. The following is a brief outline of some of the progress on specific compounds or classes of compounds being studied at the Galveston laboratory.

The N-ethyl-carbazol substances ("carbohydrates"). There are substances in sea water which respond as carbohydrates to the N-ethyl-carbazol test. These may or may not be true carbohydrates, and until we are certain of their identification the provisional term "N-ethyl-carbazol substances" has been adopted. Accordingly, the values given as "carbohydrates" are always in terms of arabinose equivalents because we use arabinose standards for reference. We have isolated and concentrated two substances which respond to the test and our chemists are now at work on the identification of these compounds.

We make routine determinations of these substances on all of our oceanographic stations. They are not homogeneously distributed at all, and we feel that they are associated with phytoplankton production. The reasons for this are: (1) in the early work (Collier *et al.*, in press) we found that in five-gallon bottles the production of the substances was associated with light as well as with aeration; (2) there was a clear diurnal variation of concentration in the natural waters, with

FIGURE 1

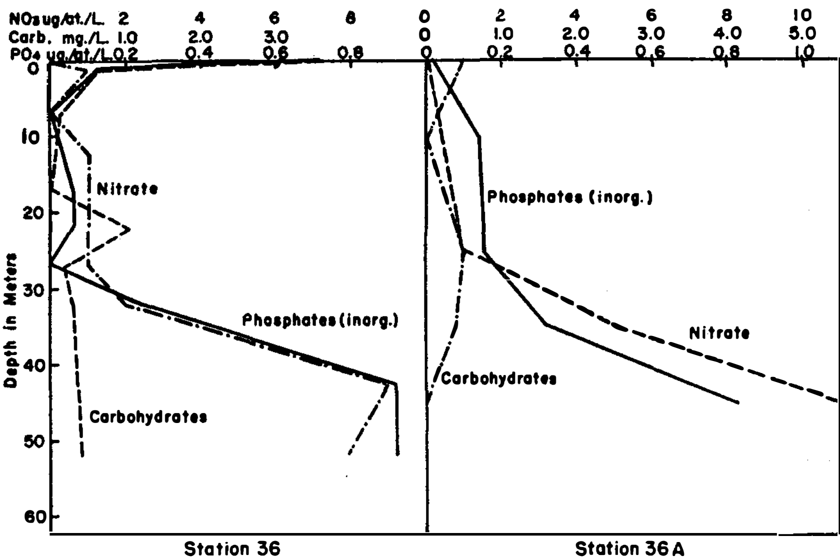


the minimum coming about 1 o'clock in the morning and the maximum in mid-afternoon.

On one of our routine cruises in the Gulf of Mexico a bloom of microorganisms was encountered and some detailed studies were made. Figure 1 shows the vertical distribution of the carbohydrates and other factors as they occurred in the bloom and just at its edge. The bloom was mainly composed of an unidentified ciliate.

The research vessel *Alaska* is equipped with an automatic plankton sampler which was designed to sample copepod populations continuously in hourly components. Figure 2 illustrates the hourly variations or carbohydrates and other chemical parameters sampled simultaneously with the hourly fractions of the plankton sampler. There are a number of important implications here that do not fall within the

FIGURE 2



scope of this discussion, but the point to be demonstrated is the type of distribution to be expected and how it fits in with the idea of patchiness in plankton distributions. The area in which the chemical factor showed pronounced maxima is biologically distinct from that in which they are at their minima.

Tyrosine and tryptophane. These amino acids are being determined routinely on all oceanographic stations occupied by the *Alaska* and their vertical and horizontal distributions studied in relation to the plankton community. We cannot, of course, say that the values we get for these represent amino acids in solution, because they may indicate the presence of intact proteins from which we get the acids on hydrolysis. The important thing is that we find measurable quantities which may represent up to 50 mg. of protein per liter if tyrosine is taken as 4 per cent of a protein molecule.

Rhamnoside. This sugar complex has been isolated (Wangersky, 1952) and concentrated in crystalline form in a number of instances from tidal marshes, open ocean, and more recently from the Florida red tide of November, 1952. In the latter case it was extracted at the rate of 50 mg. of crystalline material per liter of water. We have no routine test for this material, and, as yet, are not sure of its chemical structure.

Ascorbic acid. Minute quantities of this compound were isolated and identified spectrometrically (Wangersky, *loc. cit.*). It is only to be expected that this and other vitamins would be in sea water which is supporting a great amount of activity, both plant and animal.

Unidentified compounds. In the course of this work a number of distinct fractions have been isolated chromatographically and await chemical identification and testing for biological activity. Among these are some relatively abundant substances which appear to be carbohydrate derivatives of low molecular weight (two or three carbon atoms). These are particularly interesting because some of their characteristics fit in the pattern of the N-ethyl-carbazol substances mentioned above.

In the bottom sediments from the Gulf of Mexico taken at 1,700 fathoms we have found yellow lipoid materials which give a bluish fluorescence under ultraviolet light. These may or may not be related to the substances mentioned by Kalle (*loc. cit.*).

THE SIGNIFICANCE OF THE COMPOUNDS IN THE MARINE COMMUNITY

1. As energy source.

As already mentioned, much of the interest in this subject has been in the nature of controversy regarding Pütter's theory. It is entirely possible that at least some organic materials are adsorbed on inert particles and then ingested to be stripped, as it were, for easy assimilation by the organisms. We are particularly interested in investigating the possibility of using this mechanism in the rearing of very young fish.

2. As growth promoters and inhibitors.

This may well be the field in which dissolved organic compounds have their greatest significance. The importance of the micro-biota in the marine economy needs no emphasis. Neither is it necessary to emphasize the fact that a great proportion of this segment of marine life derives its nourishment from the utilization of dissolved substances. If growth-promoting substances are found to be necessary in experimental nutrient solutions used in the culture of various planktonic organisms, it is likely that they will also be required in a normal environment. For instance, it has been found that several planktonic organisms will not flourish without the addition of soil extract to the artificial media used in their culture (Sweeney, 1951). Hutner and Provasoli (1951) reflect that "A mud or soil with an abundant and varied microflora should contain very nearly the gamut of microbial metabolites; . . ." Lake drainage, tidal marsh and estuarial effluents can all be considered as soil extracts which have been manufactured on a grand scale.

Once enriched by an organic bearing land effluent, some sea areas establish their own milieu which, in turn, evidently can produce growth promoting substances of their own. Large over-blooms of dinoflagellates must have their origin in something of this sort.

We plan to try some of the substances that have been isolated from such blooms and purified in our laboratories as growth promoters on young fish, as well as on various microorganisms, particularly the dinoflagellates associated with the Florida red tide.

Another candidate for significance in this area would be the caretenoid residues from the phytoplankton. These can be found in both sediments and water columns in extractable quantities and their influence on the marine fauna, micro and macro, should most certainly be given detailed attention.

Metabolites can limit populations as well as assist their proliferation. Pratt (1943) found that a water soluble extract from old cells of *Chlorella Vulgaris* retarded photosynthesis in young cells. He improved the growth of his cultures by providing means of removing these metabolites. The importance of the study of such compounds in connection with phytoplankton blooms is obvious.

3. As regulators of feeding activity.

Collier *et al.* (*loc. cit.* in press) have demonstrated the relationships existing between unknown "carbohydrate" compounds (N-ethylcarbazol substances) and the filtration rate of oysters. There appeared to be a threshold beneath which the oysters would not pump water, but above which there was a quantitative association. More carbohydrates seemed to be required when the water temperatures were higher. The oysters exhibited testing periods during which the valves opened only to a certain point, and beyond which they would not open unless the carbohydrates were at threshold level or over. This testing was at random, and at times periods of high carbohydrate would be allowed to pass undetected because the oyster failed to make a test opening. It is possible that this mechanism serves to keep the oyster from expending stored energy on pumping sterile water.

4. Effects on the movements of animals.

An extension of the above effects of organic compounds on oysters could be made into the field of fish behavior. If oysters have the neurosensory systems capable of detecting and acting on such stimuli, there is no reason to think that a similar mechanism could not exist in fish.

Stevens (1949) cites supporting evidence that fish such as mackerel and herring avoid water heavily populated with phytoplankton such as the diatom *Rhizosolenia* or the flagellate *Phaeocystis*. On the other hand he relates that mackerel are caught most in so-called yellow water which is rich in copepods.

A study of the organic compounds exuded into the water by these different populations and the effects of these compounds on fish would certainly be rewarding.

5. As toxins.

We have here only to mention the great fish kills which are laid at the door of large blooms of dinoflagellates of various species. Riegel *et al.* (1949) isolated definite toxins from blooms of *Gonyaulax catenella* which had a toxicity of 1.65 mouse units per microgram. A mouse unit is that quantity of poison which will kill a 20-gram mouse in 15 minutes when injected intraperitoneally.

The author experimentally killed *Fundulus* sp. and *Cyprinodon* sp. with small quantities of water from the November red tide in Florida. This water was quick frozen upon collection and was held in the frozen state for a month before the experiment, and fish were killed in less than 20 minutes by a 4 per cent mixture of this water. The same water held at room temperature from the time of original collection was not toxic. It is hard to avoid the conclusion that this water, in its original state, held in solution some organic compound which acts as a poison to fish and which was stabilized by quick freezing.

6. As aid in evaluating biological activity of discrete water masses.

It appears that some of these compounds might be produced in the early phases of the photosynthetic process, and some in the anabolic phases of a phytoplankton community. In any case, their concentration and distribution would be dependent upon the size of the colony of organisms producing them, the activity level, and the potential productivity of the water supporting the growth. It should be possible, then, to obtain valuable information on the productivity of ocean waters by an analysis of these factors. Such studies could be at the level of short-term variations of activity within patches of plankton by analysis for the more volatile components, while a long-range approach over a greater area could be had through a study of the more stable residues.

SUMMARY

That sea water contains a significant quantity of dissolved organic compounds is a long recognized fact. More recently, biological differences between waters have been proven and their effects on the survival of invertebrate larvae demonstrated. It has been shown that substances which may originate in the photosynthetic process have a direct and quantitative influence on the feeding rate of oysters.

In the laboratories of the Gulf Fishery Investigations of the U. S. Fish and Wildlife Service carbohydrate and proteinaceous substances are being isolated and purified for experimental testing on living organisms, including young fish and dinoflagellates.

The principal fields of possible significance of these compounds are: as an energy source; as regulators or stimulators of feeding activities; effects on movements of marine animals; toxins; and in the evaluation of the biological activity within discrete bodies of water.

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DISCUSSION

DR. MCHUGH: One of the chief criticisms of the conventional method of measuring productivity of the sea has always been the fact that what you were measuring is really a standing crop rather than the total amount of potential productivity of the area.

I think this work of Mr. Collier's has great promise of perhaps bypassing that difficulty; also, as he pointed out toward the end of his paper, these substances are supposedly uniformly distributed throughout the water mass, rather than occurring in chunks as plankton does. We will look forward to the development of this work with interest, I am sure.

I am sure some of us must have some questions to ask Mr. Collier in regard to his methods and to the possibility of utilizing his work for these various purposes he has described.

CHAIRMAN HUBBS: I would like to ask Mr. Collier a point which he did not bring out particularly, whether he is inclined to believe that these sugars or other dissolved materials of that sort are actually utilized by the fish by being absorbed through the gills and utilized in the nutrition of the fish?

MR. COLLIER: I am afraid, Dr. Hubbs, in this case, I might have to resort to the work on oysters; I hope I might be forgiven for that. We did measure the removal of the carbohydrate substances from the sea water by the oyster in our work, and we found it was removed as the water passed through the oyster. We are not prepared to say that this was actually utilized by the oyster physiologically because it is entirely possible that the material might have been absorbed on mucous train and voided with the feces, rather than being ingested. There is, of course, in the literature now a rather increasing amount of evidence that these compounds, after all, might be absorbed by organisms from a solution of water.

CHAIRMAN HUBBS: Even if the concentrations were fine in the sea water? I think that is one criticism we have always put to the old belief that these materials were significant.

MR. COLLIER: Do I gather that you mean the amounts present in sea water would not be sufficient to support an organism?

CHAIRMAN HUBBS: Either that or that they would not utilize it at that concentration.

MR. COLLIER: Well, of course, that would depend on the size of the organism, its body surface and so on, the demand of the organism for such substances, and whether you would take the point of view that the organism would survive on these substances.

It is entirely possible that, even at low concentrations, they might provide for supplements to the field.

CHAIRMAN HUBBS: Have you in mind any investigations with radioactive material to determine if the material or organic matter actually finds a place in the oyster or fish?

MR. COLLIER: No, sir, not in the immediate future. Of course, we realize the value of that particular technique and that is being used in certain cases by another laboratory of the Service. We have considered that; but, in our laboratory, we do not have the facilities and it is not in sight.

DR. HUGH BENNETT: I just wanted to ask if these organic substances are in complete solution or possibly some of them in some such state as colloidal suspension.

MR. COLLIER: In our work, we did run water through bacteriological filters; but, of course, that does not mean that we might not have had some very fine colloidal suspensions. It all depends on whether you want to establish the boundary.

DR. MCHUGH: I would like to ask just one more question. That is, you have shown that these substances have some effect on the feeding activities of the oysters. I wonder if you have considered any work on the possibility of their having an effect on the spawning activities of oysters and other mollusks.

MR. COLLIER: We have not studied them in relation to spawning activities. Of course, we all know of Nelson's work with the hormone, dianaline. That is something produced by the oyster itself. We have not gone into this, after all.

CHAIRMAN HUBBS: In partial answer to Dr. Bennett's question, I might say that we have research going on at the Scripps Institution of Oceanography, which indicates that the particular organic material in the sea, the remains of the organisms, some of which is in virtually colloidal state, is probably of tremendous significance in the nutrition of the filter-feeding organisms, such as the mussel and oyster, and a great many others. Some of our men there in biochemistry feel that this sort of material is probably more significant in many places, and at many times, than the actual living plankton itself.

DR. MCHUGH: If there is no more discussion of this paper, I will turn the floor back again to Dr. Hubbs.

CHAIRMAN HUBBS: We now have a bit of shift in our line of papers here, from those dealing with the fishery products and the organic materials which are basic thereto, to a series of papers on marine mammals, a subject which I know will be of very great interest to all of us.

The first of these papers is by Richard E. Griffith, of the Fish and Wildlife Service, dealing with the future of the sea otter.

WHAT IS THE FUTURE OF THE SEA OTTER?

RICHARD E. GRIFFITH
U. S. Fish and Wildlife Service, Washington, D. C.

The sea otter is one of our most neglected wildlife resources. Consider its former abundance and value. In 1804, 15,000 skins valued at $1,000,000 were contained in one shipment made from Sitka. Even as late as 1885, 4,152 skins worth over $1,500,000 were taken in Alaskan waters; more than 1,500 of these came from the Kodiak district, which included Cook Inlet and Prince William Sound. Today, there are less than 500 otters in the same area.

The exploitation of this resource began on the Kamchatka coast early in the eighteenth century. As their numbers decreased here and in the Kurile Islands, new hunting grounds were sought among the Aleutian Islands, the Alaska Peninsula, and, finally, southward along the coast to California.

Steller (1899) mentions the natives of Kamchatka referring to the sea otters as visitors from a foreign land, as sizable numbers were brought to that shore on ice floes after two or three days of a strong east wind. Apparently, much of the hunting depended on this aberrant dispersal, as Steller reported few otters were killed there because of the mild winters and lack of ice from 1740 to 1743.

Returning from the second voyage of Alaskan waters in 1741, Bering's ship, the *Discovery,* brought several hundred otter pelts. Apparently, these were taken in the Commander Islands where the ship was beached for the winter to permit repairs. This find spurred the interest of others, and by 1769, 25 to 30 different fur traders were active in Alaskan waters.

Records kept by the Russians at the Siberian ports of Okhotsk, Bolsheretzk and Petropavlovsk convey some idea of the size of the sea otter populations in the North Pacific. The following figures compiled by Petroff (1884) are probably conservative, as the government levy on skins brought to port encouraged some smuggling.

SUMMARY OF FURS SHIPPED FROM RUSSIAN AMERICA

Shipper	*No. of Pelts*
Siberian traders, 1745-1797	96,047
Shelikhof Company, 1786-1797	15,647
Russian-American Company, 1798-1822	86,644
Russian-American Company, 1822-1842	25,416
Russian-American Company, 1842-1862	25,899
Russian-American Company, 1862-1867	11,137
Total	260,790

An unknown number of pelts was delivered to ports in China and Europe.

The largest single shipment on record is 16,000 pelts unloaded at the port of Okhotsk in 1770. In 1786, the first year the Pribilof Islands were occupied, 5,000 otters were taken there. Two thousand were killed the following year. Within six years, the last otter disappeared from here, and none has been seen since.

Two to three thousand pelts were taken annually in some localities over a period of several years during the early part of the nineteenth century, only to have the animals disappear for a time and then recur. According to Elliott (1875), the Russians took 1,000 otter pelts from Unalaska in 1804; in 1826, 15 pelts; in 1835, about 100 were taken; and in 1867, the entire yield from the Aleutian chain was only 600 to 800 pelts. Elliott reported that the American hunters secured about 4,000 skins from this area in 1873. Aided by the long-range rifle, hunters took 6,000 to 8,000 skins from the Unalaska area between 1880 and 1881.

On at least three different occasions, agents of the Russian-American Company on Kamchatka and the Kurile Islands claimed that the sea otter had become extinct there.

About 1880, there was evidence of a general eastward migration. The sea otters began to reappear in Cook's Inlet where formerly they had been almost exterminated. Otters were now comparatively abundant in the Sannak-Belkovsky area where, within a radius of 50 miles, more than 2,000 otters were taken each year during the last half of the nineteenth century. They were still numerous in the vicinity of Kodiak, Cook's Inlet, and Prince William Sound toward the close of the century as indicated in the following records:

APPROXIMATE NUMBER OF SEA OTTER TAKEN IN ALASKAN WATERS BY ALEUTIAN ISLAND NATIVES EACH YEAR FROM 1873 TO 1896, INCLUSIVE[1]

Year	Attu	Atka	Umnak	Unalaska	Sannak	Akutan	Morzhovoi	Belkofski and Wosnessenski	Unga	Kadiak	Total
1873	141	129	195	54	477	85	221	754	209	......	2,265
1874	27	151	224	237	892	58	263	445	139	......	2,436
1875	105	444	240	208	920	76	176	430	75	......	2,674
1876	67	155	141	310	980	45	255	784	149	......	2,786
1877	14	236	166	226	520	35	214	621	152	440	2,624
1878	59	132	104	197	700	43	264	834	248	426	2,989
1879	20	211	105	88	765	9	259	809	254	601	3,121
1880	11	142	73	38	694	6	226	800	216	808	3,014
1881	22	57	33	21	995	11	213	752	293	602	2,999
1882	6	73	14	35	975	14	114	792	233	858	3,114
1883	3	69	84	49	820	26	179	1,187	371	1,010	3,798
1884	6	54	44	24	912	41	256	838	553	1,244	3,972
1885	4	84	57	13	797	29	285	903	472	1,508	4,152
1886	5	122	26	11	853	8	156	707	346	1,375	3,604
1887	5	58	46	12	737	5	160	734	346	992	3,095
1888	..	64	21	12	643	5	94	398	257	1,002	2,496
1889	1	51	16	9	476	3	108	313	173	655	1,795
1890	2	35	2	6	466	1	68	272	116	666	1,633
1891	1	39	6	13	486	1	33	202	72	583	1,436
1892	..	29	6	1	171	..	30	132	189	362	820
1893	1	26	5	1	132	2	36	140	37	306	686
1894	..	26	1	1	204	1	32	71	42	220	598
1895	2	24	..	..	318	1	24	23	57	428	887
1896	..	21	..	..	324	2	18	16	72	322	724

[1]Hooper, C. L., *A Report on the Sea Otter Banks of Alaska*, Government Printing Office, Washington, D. C., 1897, p. 16.

By 1897, the sea otter had nearly disappeared from its Attu haunts; in fact, only a very few had been taken since 1882. In July, 1896, personnel of the American schooner *Challenge* reconnoitered this general area for a period of 18 days of good weather during which not a single otter was seen. None was observed on the Buldir Island banks since 1874, and Hooper (1897) reports that around the close of the century Kiska and Amchitka were entirely abandoned, as were Seguak, Yunaska, Amukta and the Islands of Four Mountains. They also left Umnak, and only a few were taken on the Unalaska banks. During the ten-year period from 1888-1898, the annual otter catch at Akutan never exceeded three, and they had become almost extinct on the Sannak grounds. The Morzhovoi habitat was almost hunted out by 1897, and the Belkofski area, which produced 700 skins in 1888, yielded but 16 in 1896. Hunters frequently obtained 300 to 400 otters each year from the Unga district, but by 1896, only 22 skins were secured. In 1897 the principal otter habitat was located on the banks to the southwest of Kodiak.

Data on the sea otter seem to be few for the period 1900-1935. During a routine patrol of Amchitka Island in the summer of 1935, Coast Guard personnel counted 600 sea otters where 38 years earlier none was reported. In his report on biological investigations conducted in the Aleutian chain during the summer of 1937, O. J. Murie *et al.*

(1937) listed 1,000 sea otters for the Amchitka area, 200 at Tanaga Island, 150 at the island of Kavalga and a few at Ogliuga. Otters were observed at Kiska, Semisopochnoi, Gareloi, West Unalga, Ulak and Ilak Islands. Murie mentioned that natives, as well as others, reported seeing otters on Amlia, Unalaska, Chignik, Sutwik, Semidi and Chirikof Islands. His party visited Sanak and Unimak Islands, once favorite hunting areas, but saw no otters, nor were there reports of any having been present.

On the basis of actual counts and reliable reports, Murie estimated a population of about 2,000 sea otters in the Aleutian area at that time. Just how much their numbers may have increased since the taking of pelts was outlawed in 1912 is a matter of conjecture. There was positive evidence of otters appearing in new locations.

To date, no satisfactory explanation has been found for the variation in numbers observed in the Amchitka area. Possibly, the otters make periodic migrations in search of food or for other reasons. There is an indication of some seasonal movement in recent records for Sutwik Island where 41 otters weer seen in January, 1949, and 355 in the summer of 1951. Three otters were counted during an aerial survey of the Shuyak Island in December, 1948, whereas 60 were observed here in July of 1951. There have been significant variations in the Amchitka population also. For example, Coast Guard personnel counted 600 there in the summer of 1935 and 804 in 1936. Sea otter wardens Loy and Friden, stationed on the island from July 11 to September 1, 1937, in an unpublished report estimated the total number at more than 1,700. On the basis of observations during a similar period in 1938, Loy and Hewitt estimated the Amchitka population for that year at 1,030 otters. Loy was on the island from January, 1939, through the summer, and on the basis of extensive observations from shore and boat, estimated the population to be about 1,700 otters. He reported an actual count of 1,355 otters, a 31.6 per cent increase over the 1938 count.

On the basis of a thorough aerial reconnassaince made June 24, 1943, under good weather conditions, former Refuge Manager Frank Beals estimated that there were 3,420 sea otters around Amchitka. Refuge Managers Jones and Spencer reported counting 1,324 otters around Amchitka and Rat Islands during an aerial survey in August, 1949. Their record indicates 1,087 otters were in the Amchitka area. There is evidence also that some groups are quite static. For example, a partial count (559) along the south side of the island made in 1949 indicates no great change from numbers observed in 1937 (680).

A census of the otters is difficult to make, even under favorable conditions, and experience has shown many animals may be missed because of their diving for food, rough water, or being concealed among the shoals. The accuracy of the several Amchitka counts is open to question; nevertheless, the trends indicate over a period of years a probable resident population of 1,000 to 1,500 otters, with occasional influxes from other colonies.

The possible extent of losses from disease is unknown. Steller mentions dying otters being found occasionally on the Kamchatka shore, and suggests such losses were from old age or injury, rather than disease. Loy, who was on Amchitka during the summers of 1937 and 1938, and from January, 1939, to September of that year, makes no mention in his daily log of finding sick or dead otters. There was no record of losses in daily logs kept by other sea otter wardens stationed on Amchitka between 1937 and September, 1940. The remains of six animals were collected on Amchitka beaches in 1947, 20 in 1948, and 92 in 1949. In the spring of 1951, efforts to transplant otters from Amchitka failed as the entire number taken (35) died within a day or so after capture. While this project was active, several dead otters were found along the shore. The cause of these losses is still unknown.

To what extent the otters may reoccupy their former range has been a matter of speculation. After forty years of protection, and for reasons yet to be determined, they have shown no signs of recovery in some areas. In spite of past intensive hunting in the Commander Islands, some 600 to 700 otters were reported there after 1930 (Barabash-Nikiforov, 1935). An item of interest regarding the occurrence of otters in the Kuriles was mentioned in a report which a Coast Guard skipper made to the Bureau of Fisheries. In the summer of 1935, a Japanese fishing vessel entered Dutch Harbor, Alaska, while a Coast Guard cutter was anchored there. An aquatic biologist, Katsumi Miyataki, of the Japanese Bureau of Fisheries staff, Tokyo, was on board the fishing boat. In discussing the sea otter situation in the northern Pacific, Miyataki stated that there were about 2,000 in the Kuriles. He mentioned that his studies indicated the average annual increment was about 10 per cent, also that the females bore young but once every two to three years. Such a low biological potential, coupled with natural losses and epizootics, may be the explanation for the apparent lack of increase in some of the Aleutian areas.

It has been suggested that some otter colonies, such as Amchitka, have reached the carrying capacity of the habitat. Rather fragmentary population data indicate that this may be true; however, the lack of funds has prevented conducting field studies needed to determine food resources and other factors which may govern the abundance of local populations. The kill records which Hooper compiled for some areas show annual takes for several years of a much larger number than is now present after 40 years of legal protection.

Present knowledge of the distribution and abundance of the sea otters is based on limited data gained through partial surveys of the former range. The lack of funds has prevented making a comprehensive survey of the otter grounds currently occupied or of large areas of promising habitat where, formerly, the animals were abundant.

Just how much dispersion can be expected as the carrying capacity of an area is reached will have to be determined by the development of a satisfactory marking technique and more intensive studies of population trends. The information at hand indicates that consideration should be given to a regulated take in those areas where the population appears static. Without regulation, the fur resource which has been built up gradually over four decades could be pushed back to the verge of extinction in the space of a few years.

It has been suggested on numerous occasions that the sea otter might be raised in captivity and thereby afford greater opportunities for carrying out management studies. The lack of success thus far in keeping animals alive following capture does not justify following such a proposal. In addition, field research must be undertaken on many problems relating to the management of the sea otter resource.

The future of the sea otter will be determined by the quality of management. Successful management must be based on fact rather than inadequately supported theory.

The long-range objective of management is the restoration of the sea otter to a population approaching in size and distribution that in early Alaskan history. Since few known changes have occurred in the habitat during the past two hundred years, such an objective appears within the realm of possible accomplishment.

Current management objectives are:

1. A more comprehensive aerial survey of known otter grounds and the more promising habitats located among those islands now inhabited.

2. Conduct intensive field studies in order to obtain needed information on reproduction, foods, mortality factors, longevity and movements.

3. Determine the significance of recurrent winter die-off, the underlying causes and possible remedial measures.

4. Determine the best methods of taking, handling and marketing of skins.

The value of sea otter pelts on the present fur market is unknown. In the past, most of the pelts were sold on foreign markets. Since 1900, comparatively few otter pelts have been available. The value of several skins from Japan which were handled by an American auction house a few years before the war ranged from 600 to 900 dollars. There is some question as to the possibility of a demand for sea otter pelts in this country, and their acceptance in foreign markets can only be determined when the pelts are channeled into the fur trade.

The time has arrived when we should choose between a regulated take of this once fabulous resource, or simply continue legal protection and disregard their potential contribution to the economy of Alaska. After being protected for the past forty years, the sea otters are recovering and are sufficiently abundant in portions of their range to warrant management studies involving the removal of the annual increment. Present indications are that the sea otter will again become an important economic asset in a significant portion of its former range.

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DISCUSSION

DR. MCHUGH: Thank you, Mr. Griffith. I would like to ask one question. Perhaps I missed it in listening to your talk. What is the presently known southern limit of the range of the sea otter?

MR. GRIFFITH: That is a question we cannot answer very satisfactorily. We know that, on the basis of such limited surveys as it has been possible to make in recent years, the population is in excess of 2,000 animals and has been estimated at approximately 5,000 animals. It may be considerably greater than that; it may be somewhat less than 5,000.

DR. MCHUGH: I was interested particularly in knowing how far they range to the southward in the Pacific.

MR. GRIFFITH: You mean at the present time?

DR. MCHUGH: Yes.

MR. GRIFFITH: There are a few which get down in the vicinity of Ketchikan, and occasionailly a single or a pair of otters is seen below there.

But, so far as we know, the northern population has not extended its seasonal range down as far as the north end of Vancouver Island. We would say that the present eastward extension of its range is probably in the vicinity of Kodiak, Cook's Inlet and Prince William Sound. There are fairly large numbers in that area at the present time; but, eastward and southward from there, only an occasional otter is seen.

DR. MCHUGH: The purpose behind my question was that I was wondering whether there was any possibility or whether there was any evidence that fluctuations in the abundance of some of the more abundant food fishes in the mass might have some effect on the movements of otters, and also on their abundance. For example, it is well known that the sardine abundance has declined very markedly in the last fifteen years, and perhaps declines in the abundance of other species lying within the range of the otter might have effect on both their movement and their abundance.

MR. GRIFFITH: There again that has to be a matter of speculation from the standpoint of our present knowledge. The food resources, as far as we know, have not changed at all over the period of the last 200 years, during which the otters were taken in Alaskan waters. The principal populations were in the West Aleutians, where there has been relatively little commercial fishing. At the present time, the largest populations are in areas where there is some seasonal fishing activity for salmon, but our present information would indicate that the fishing has had no traceable effect on the sea-otter movements or their relative abundance.

DR. MCHUGH: Thank you.

I do not want to ask all the questions. Does anybody in the audience have a question or a comment they would like to make?

CHAIRMAN HUBBS: I might partly answer your query. The sea otter, of course, feeds primarily on shellfish and sea urchins and other organisms; so the fishery could only affect it if the fishermen took some sea otters, or frightened them away from the grounds or something like that. Is there any evidence that the sea otter feeds on other species?

MR. GRIFFITH: Yes, there is evidence that they feed on the kelt generally. As far as I know, that is not a fish of commercial importance. Whether they feed on some of the fish which are taken commercially, we cannot say, from the basis of our present knowledge of the food habits of the otter.

DR. MCHUGH: The fur seal has responded so well to management that it is very interesting to hear that there is some possibility that the sea otter can also be managed in the same way. Perhaps the problems are somewhat more difficult, but it is encouraging to know that there is some hope.

Any more discussion?

MR. VERRITY (California): Are there any reports as to the area of the Monterey Coast in California as a successful location for otters to make a comeback?

MR. GRIFFITH: I am sorry I cannot answer that question; I am not familiar with the status of that Monterey sea otter population. I believe Dr. Hubbs may be able to help on that.

CHAIRMAN HUBBS: I cannot give you any official count; I have not been following that. I do know that the herds move up and down the Coast considerably; they are rather difficult to locate. I have seen them as far south as Southern Monterey County. It is an interesting situation there as to what happened to them during the long period when they were thought to be extinct. I happened to get over to that coast as a matter of a full day's pack-animal trek, to get over to Southern Monterey County, and happened to see one sea otter on the refuge, which I thought was a remarkable record, because all the books said they were extinct at that time. Later I found out the checker knew they were there all the time, but he would not even tell his fellow scientists for fear somebody would go down and collect the last individual. (Laughter)

I have hearsay evidence that there were a few sea otters on Guadalupe Island as late as about 1928; but our surveys there have given no indication that any remain that far south. They remained in the Sacramento refuge off the lower California Coast until approximately the 1920's or 1930's, but we have not seen them there in recent years either.

DR. MCHUGH: Do we have any more discussion?

MR. BUTCHER (Washington, D. C.): Have any been seen recently off the California Coast, anywhere along the northern California Coast?

CHAIRMAN HUBBS: Yes, that is what I was speaking about.

MR. BUTCHER: I meant whether they have been seen lately?

CHAIRMAN HUBBS: Oh, yes; there is a population of several hundred along the coast of Central California, between Monterey and, well, along the Coast of Monterey County from Monterey southward over quite a stretch of coast. They can be seen there, feeding and playing in the kelp at almost any time one wishes to search for them long enough. It is rather difficult to see them quickly, because they live in the beds of one of the giant kelp species which has a floating bladder just about the size of the head of the sea otter. So you have to watch fairly carefully in those areas to pick them out; but once you get them, particularly with glasses, you can observe them and they are rather tame at the present time.

I do not know whether there is any evidence of any poaching there, and I do not know whether there is in Alaska; I presume there is a little, as such things usually happen everywhere.

MR. ELKINS (Alaska): I would like to second what Griffith has said about the possibilities of some economic use of the sea otter before too long. But there is one word of caution which is that it will not be as simple as with the fur seal, and probably will take quite a bit more doing. They do not haul out in numbers like the fur seal. The first thing to do is to determine whether they are polygamous; then how easy it will be to distinguish the males from the females, if they happen to be taken from open waters or on reefs. The sexes can be distinguished all right when they are swimming on their backs; but it will not be nearly as easy with the bachelor.

DR. JOHN BUCKLEY (Alaska): Is there any evidence of movement of these animals in the Aleutians, between islands?

MR. GRIFFITH: It is my belief, after reviewing a considerable historical data on the sea otter, as well as current information compiled by the Fish and Wildlife Service personally in Alaska, that there is seasonal movement there. I think the census data, even though it is limited, indicates beyond a doubt that sometimes this movement may be considerable. The population shifts which occurred at Kamchatka over a period of years do not leave any question in my mind about substantial seasonal shifts. I think the variations in the numbers observed around Sutwik Island give some indication of that, too.

Of course, there is the thing to keep in mind, that the otters are rather difficult to census and it takes a keen observer, a person who knows what he is looking for, to be able to make a comprehensive survey of the otter.

It is for that reason that I mention that some of the census data was open to question. But, beyond the reasonable variations in population data as compiled, I think there is good evidence of seasonal shfits.

BEHAVIORAL FACTORS AFFECTING SOCIAL STRUCTURE IN THE ALASKA FUR SEAL

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The Alaska fur seal (*Callorhinus ursinus*) which offers the classic example of effective management of a population of wild mammals, has been more extensively studied than any other marine mammal. The general outlines of its life history have been familiar for many years; for example, see Osgood, Preble, and Parker (1914). During fall, winter, and early spring the animals are strictly pelagic; the females and young scatter widely over the north Pacific Ocean; the adult males remain in the vicinity of the Bering Sea and the Aleutian Islands. In late spring the adult males (harem bulls) come ashore on the Pribilof Islands, establish territories spaced more or less evenly over the rookeries, and await the coming of the females (cows). The pregnant females and the young nonbreeding males (bachelors) start coming ashore in the middle of June and continue to do so through July and early August. The cows are apportioned among the harem bulls. Most of the nonbreeding males station themselves inland from the breeding animals. Within a few days after their arrival the females bear their pups and come into heat shortly thereafter. After mating they spend the rest of the summer feeding themselves at sea and nursing their pups on land. During the entire breeding season, which lasts approximately two months, the harem bulls stay in their territories without eating or drinking, but the sub-adult nonbreeding males go to sea at irregular intervals. Toward the end of the breeding season, when the harems are disintegrating and the harem bulls are returning to sea, the virgin females come ashore, and at least some of them are fertilized by the young males which have not maintained harems.

Although during the last fifty years much time has been devoted to the study of the Alaska fur seal, detailed and quantitative data on the behavior of individual animals or specific groups of animals are not available. Most previous studies have been economic in purpose and have, therefore, been concerned with the population as a whole. The necessity of supplying practical answers to problems of management has precluded the possibility of prolonged detailed study of individuals or small groups. However, it is on such time-consuming and often tedious observations that the solution of some of the intriguing problems presented by these unique and spectacular animals rests.

During the summer of 1951, I had the privilege of making just such an intensive study of a small undisturbed group of fur seals. The quantitative results of this research have been presented elsewhere (Bartholomew and Hoel, 1953). Although the importance of statistically analyzed quantitative data for interpreting the behavior of vertebrates can hardly be overemphasized, carefully recorded, detailed, qualitative observations offer an otherwise unobtainable insight into the factors controlling the behavior of wild animals. In this paper I have extracted from the mass of incidents recorded in the field those patterns of behavior which are of particular importance in determining the social structure to which management procedures have been so effectively adapted. It should be emphasized that other biological factors also contribute to this social structure. For instance, physiological factors such as the timing of estrus, duration of pregnancy, the ability of bulls to go without food and water for six weeks or more, and the capacity of the pups to go without nursing for a week or more, form the foundation on which fur seal social structure rests, but these nonbehavioral factors lie outside the scope of the present effort.

METHODS

The technique of study was the obvious one of careful and extended daily observations of the undisturbed animals and the detailed recording of their behavior at the time of observation. Although all of the rookeries on St. Paul Island were visited at one time or another, the study was confined primarily to an isolated group of 20 harems in Kitovi Amphitheater which lies at the extreme north end of Kitovi Rookery. Between June 26, 1951, when systematic observations were begun, and August 6, 1951, when they were terminated, slightly over 220 hours were spent observing the harems in Kitovi Amphitheater. Partly to avoid disturbing the animals, but also to get out of the miserable weather which characterizes the Bering Sea, observations were made from a blind overlooking the study area.

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BEHAVIOR OF MALES

Much of the published material on the behavior of male fur seals has been based on nonconsecutive observations and often on episodes inadvertently precipitated by the observer's presence. The social status of the animals observed has often been uncertain and in virtually all cases their previous histories have been unknown. Consequently, the spectacular and the unusual have often been overemphasized. The present analysis, based on hundreds of hours of observation on a few known individuals, attempts to evaluate male behavior as a whole and to place it in perspective with relation to the social structure of the breeding population.

During the breeding season, the behavior of the harem bulls has three primary themes: (1) rigorous territoriality, (2) harem maintenance, and (3) copulation with estrous females.

TERRITORY MAINTENANCE

The most important single factor in the reproductive performance of the adult bulls is an uncompromising aggressiveness which is associated with harem maintenance. The agressiveness expresses itself in several ways; vocal threats, threatening charges, fights between pairs of bulls, and mobbing of one bull by several others. All are strongly affected by the spatial location of the animals concerned, for attachment to a restricted territory is probably more strongly developed in breeding male fur seals than in any other mammal. The successful establishment and maintenance of a territory on the rookery is a necessary prerequisite to effective reproductive performance by a bull. During most of the breeding season, territory maintenance and harem maintenance form an inseparable pair, but territoriality by itself may be observed in the late spring and early summer before the cows have have begun to arrive.

Individual aggression. Before the first females arrive a fur seal rookery is a relatively placid place. The bulls are spaced more or less regularly; closer together in rough terrain, farther apart in smooth, open terrain. For the most part they lie in their respective territories, sleeping, or resting quietly. At irregular intervals, usually varying between 10 and 20 minutes, a bull spontaneously rouses itself and moves toward one of the adjacent bulls, which in turn rouses itself to meet the aggressor. The two meet face to face at the boundary between their territories. They threaten with growls and snorts, shake their heads from side to side, and make rapid, darting, open-mouthed thrusts at each other's heads and necks. As one animal thrusts, the other jerks its head back. When the first animal has its neck fully extended, the second strikes back. Thus they fence in a series of alternating, darting blows which, though vicious, rarely make contact. After a few seconds the "attacking" animal retires and both animals return to their slumbers. Occasionally this pattern is varied by two animals simultaneously charging violently toward each other and then throwing themselves flat on their bellies, sliding to halt, each with its snout at the edge of its territory, and puffing at the other like a small locomotive. These threats appear to redefine and maintain territorial boundaries—functionally they are similar to the singing of a bird at the boundaries of its territory. In the absence of females, adjacent harem bulls usually ignore each other except for these relatively formalized activities. The appearance of an unfamiliar and unestablished male, however, evokes a more aggressive response and one which does not stop at the territory boundary. The appearance of a single unfamiliar male on the slope above Kitovi Amphitheater was enough to arouse all six of the males in the innermost tier of territories, and often one or another of these would leave its territory and chase the intruding male for 80 to 100 feet across the unclaimed area inland from the rookery.

Prolonged pitched battles between established harem bulls almost never occur; their fights customarily consist of a few slashing bites or a few violent shakes which do little damage because of the dense pelage of the bulls. Harem bulls are rarely displaced during the breeding season and in proportion to the number of attempts which are made, new bulls rarely are able to move into an area and establish a territory once the breeding season has begun.

Characteristically, a bull which is attempting to establish itself does not try to displace one of the harem bulls. He merely attempts to occupy a station in the rookery, which can serve as the nucleus of a territory whose boundaries will be defined later. Such efforts are almost always defeated within a few minutes by a furious and noisy battle between the new male and the harem bull in whose territory the new male was attempting to establish himself. The intruding male is at a disadvantage. He lacks the confidence of the bull that is in his own territory, and in rough areas he also lacks a detailed knowledge of terrain and topography. Consequently even if he is as large and vigorous as the established bull he is almost certain to be defeated.

Group aggression. In addition to the factors mentioned above, a group reaction by several harem bulls virtually assures the defeat of an interloping male. The extremely severe battles in which dangerous, even fatal, wounds are inflicted occur not between pairs of harem bulls, but between groups of harem bulls and some single bull which is trying to establish a new territory. These violent general fights are an expression of the contagious nature of fur seal aggression; one aggressive act facilitates others and each one reinforces another. Thus several animals may become involved, and the more animals concerned the greater their viciousness and fury. Such group attacks were observed many times and all followed essentially the same pattern. The incident described below is typical.

Early in the breeding season (June 27) an idle bull that had been swimming about just offshore made a dozen or more sallies onto the cobbles at the water's edge during a period of two hours. Each time he was met, threatened, and driven off by the male whose territory occupied the area. Finally, while the harem bull was resting quietly with eyes closed, the idle bull left the water with a rush, scrambled inland of his adversary, and whirled to stand with his back against an overhanging boulder. As soon as the harem bull became aware of what had happened, he launched a violent and headlong series of slashing attacks which inflicted four deep gashes on the neck and front flippers of the intruding bull. The fight then subsided to a series of irregularly spaced brief attacks interspersed in a continuous uproar of vocal threats. The new male held his strong defensive position for slightly over two hours without receiving any further serious damage, but finally a particularly energetic assault knocked him out of position. He made a dash to the landward side of an adjacent territory, whose proprietor immediately launched a series of the customary slashing attacks and then seized the intruder high up on the neck, pushed him off balance against a boulder and held him there momentarily. Instantly the four adjacent bulls, including the original combatant, abandoned their territories and closed in. All ignored the harem bull, and began to shake and tear at the intruder. The intruder struggled furiously but was held down and mauled for fully 90 seconds. At last he managed to pull free and rush, a staggering, bloody mess, into the water. Blood gushed from several dozen wounds about head and neck. One eye appeared to be punctured or torn out, and one tear on the side of his neck was at least 14 inches long and gaped almost as wide. He flopped into the sea and his momentum carried him out 10 or 12 feet where he floated motionless, streaming blood and blowing heavily. Although no other instances were seen in which such severe damage was inflicted, the temporary indifference of the harem bulls to territory boundaries when a bull was pinned down was observed repeatedly. These group attacks assure the stability of the *status quo,* because any new bull in attempting to establish himself may have to contend not with just one antagonist, but with as many as half a dozen.

Although during the group attacks, the established bulls do not bother each other even though terrtiorial boundaries are being violated, by the time the intruder withdraws, as he almost inevitably must, the bulls which participated in the contest have become so wrought up that they threaten each other, and even grapple and slash briefly. The mobbing response of the harem bulls to males which are held motionless is expressed on rare occasions even when the immobilized male is a harem bull. Sometimes the "territory redefinition" behavior results in a brief fight and in one such instance one of the bulls was seized at the base of the jaw and held down for a few seconds. Bulls from the four contiguous territories immediately attacked the immobilized animal who pulled free before more than minor cuts were inflicted.

Establishment as a harem bull. Although a bull attempting to establish itself on the rookery is violently attacked, once accepted he has little difficulty maintaining status as a harem bull. Acceptance is rapid; a new male need only hold a station until the adjacent bulls get accustomed to him. If a new male does not attempt to acquire a harem immediately he can ocasionally establish himself without using physical force. At 9:10 a.m. on July 17, an adult male which, judging by its color, had not been out of the water more than a day or two, approached the inland edge of the rookery in Kitovi Amphitheater. While he was still at least 80 feet away, several harem bulls challenged him vocally and made 20- to 25-foot charges up the slope in his direction. However, he held his ground about 40 feet from the nearest territory. At 5:15 p.m. he was still there. By the next morning he had moved down the slope toward the other bulls and was only 20 feet inland from the boundary of one of the harem bulls which had apparently become adjusted to his presence. Moreover, the new bull had already developed a clear-cut feeling of territorial possession. When a transient male appeared on the slope, the new bull bugled a vocal challenge. Within a few seconds he was joined by the longer established bulls, two of which stood less than eight feet from him, threatening the new intruder.

Although a few hours of occupation of an unclaimed part of the rookery insures acceptance, if the newcomer attempts to claim part of an established territory and is not driven off immediately, an intermittent battle may last for the greater part of a day. The newcomer need not oust the harem bull. Even if he takes more punishment than he gives, he can establish himself if he holds his station.

Despite the close proximity of the harem bulls, no dominance hierarchy develops. Inside his own territory each bull is dominant to all his neighbors.

Role of vocalization. During the height of breeding activity a fur seal rookery is a bedlam of sound. With experience an observer can tell what is going on by the quality and volume of sounds produced. Harem bulls have an extensive vocal repertory; certain sounds are used in particular situations and evoke specific responses. The rattling growl, the harsh rasping pants, and the explosive growls which accompany the threats of adjacent harem bulls evoke no perceptible response except from the two bulls directly involved. The hoarse and furious fighting sounds which accompany a pitched battle excite and alert the adjacent harem bulls and sometimes stimulate them to round up their harems or patrol the boundaries of their territories. The loud trumpeting threat with which bulls whose territories abut on the unclaimed area inland of the rookery greet the arrival of transient males, however, evokes a much more general response. One of these trumpeting threats may cause an intruding male to withdraw even though he be 40 or 50 feet away. At the same time it alerts all the other males on the periphery of the rookery who then threaten the newcomer and make short charges in his direction. The harem bulls with territories inside the rookery, however, pay no attention to this vocalization.

Sexual dimorphism. The difference in size between male and female Alaska fur seals is greater than in any other mammal. The adult bull is 7 to 10 times as large as the adult cow. The evolution of this extreme dimorphism is, of course, associated with the higher reproductive rate of those bulls whose large size makes them successful in intrasexual aggression. There is also a conspicuous disparity in the age at which cow and bull reach effective reproductive maturity. The males breed only erratically until they become harem bulls, and bulls are normally ten years old or older (Scheffer, 1950) when they achieve this status. The cows, however, regularly breed at an age of four years. The long period of growth which precedes attainment of status as a harem bull has collateral behavior effects which reinforce the physical advantage of the fully mature males over their younger competitors. The experience of the older males appears to be as effective as their greater size and strength. Old battered bulls missing several of their canines —a bull's primary offensive weapon—often hold territory by bluff alone. A show of force by one of these grizzled veterans is usually enough to cause the withdrawal of a more powerful but still inexperienced young male. The lack of experience and resultant lack of confidence of the young bulls is as important as strictly physical factors in causing their almost invariable retreat in the face of a vocal threat or short charge from the established harem bulls. As a result, threat alone is ordinarily enough to insure victory to harem bulls except when dealing with each other. Consequently the harem bulls need to maintain themselves by force only infrequently. In Kitovi Amphitheater those harem bulls with territories inside the rookery actually did not have to use physical force to maintain their status at any time after their territories were established—although complete and wholehearted readiness to employ physical force was demonstrated scores of times daily during the organized breeding season.

Reaction of harem bulls to bachelors. Harem bulls react in an aggressive manner even toward young males only two or three years old. Occasionally one of these small bachelors wanders into areas occupied by harem bulls. When this happens the harem bulls advance toward the intruder relatively slowly and deliberately, often at hardly more than a walk, and usually without any particular appearance of ferocity. The bachelors invariably flee, but when overtaken or cornered, instead of showing aggressive intent, they react like females and address the harem bulls chest to chest and attempt to sniff noses. Each time I saw this happen the harem bull paused a few seconds, then seized the bachelor by the skin of the back, lifted him off the ground and shook him violently from side to side. After a few shakes the bull lost its grip and the bachelor, weighing 40 to 50 pounds, was thrown through the air for three to eight feet, spinning wildly. In two instances the shaking took place a yard or so from the edge of a 20-foot cliff and the gyrating bachelor sailed over the edge of the cliff, landed on the boulders below, and then moved slowly and painfully to the water.

Sometimes the smaller bachelors temporarily elude the harem bulls by fleeing into a harem. The bull usually gives chase, but this makes the females nervous and they begin to scatter. This in turn evokes the male's harem maintenance reaction so that he stops his pursuit of the bachelors and tries to round up his cows. In one case a three-year-old bachelor spent almost 5 hours in a harem. The cows paid no attention to him. The bull chased him intermittently.

The unchallenged nature of the dominance of the harem bulls over young adult males was illustrated very clearly three times during the period of observation when young adult bulls retreated from a harem bull until they were standing on the edge of the 20-foot cliff mentioned above. Each time as the harem bull advanced, the young bulls, instead of fighting, leaped off the cliff to land with a crash on their chests on the boulders below. Despite the violence of their falls none appeared to be seriously hurt, and all made their way to the water.

INTERSPECIES AGGRESSION

Bull fur seals react aggressively toward any large mammal, other than fur seal cows and pups, which may enter or approach an established territory. Arctic foxes (*Alopex lagopus*) are common on the Pribilofs. They can often be seen skirting along the inland edge of the rookeries scavenging fur seal placentas which are an important part of their summer diet. Usually the bulls pay no attention unless the foxes approach within eight or ten feet, whereupon they threaten vocally and sometimes charge and chase the foxes for 25 or 30 feet.

Prior to and during the most active part of the organized breeding season, harem bulls react to the approach of a human being in an extremely bellicose manner. It is unsafe for a man to enter a rookery alone and even several men armed with long heavy bamboo poles can do so only with difficulty and at a real risk. Except toward the end of the breeding season it is usually impossible to drive bulls out of their territories. They not only hold their ground, but charge repeatedly and attempt to bite. Fortunately they usually stop at their territorial boundaries.

A small number of dairy cattle are maintained on St. Paul Island. Although they graze near the rookeries they usually approach only the non-territorial bachelors or the most peripherally located idle bulls; the latter may react vocally or with short threatening charges. However, on several occasions the cattle approached the edge of Kitovi Rookery, and each time various of the harem bulls left their territories and charged furiously up the grassy slope at the cattle which galloped away.

Steller sea lions (*Eumetopias jubata*) are common in the Pribilofs and occasionally one of them will haul out near or in the territory of a bull fur seal. The latter reacts as he would to a bull of his own species. Despite the fact that fur seals are only about one-third as large as these sea lions, they charge and leap at the head and shoulders of their enormous adversaries which usually retaliate with an open-mouth threat and withdraw only a few feet at most. Prolonged battles were never observed.

DISTRIBUTIONAL RESULTS OF MALE AGGRESSIVE BEHAVIOR

The aggressiveness of the males results in a rookery dominated by a single species and occupied in a characteristic pattern by the males. The territories of adult males fill the areas directly adjacent to the sea and extend inland for a variable distance. The most inland of the bulls are the ones least likely to obtain cows. As the bachelors come ashore, they stay inland from the bulls and form an aggregation in which territories are not maintained. In the sea along the edge of the rookery, there is always present a mixed group of bachelors playing and chasing each other, and a smaller number of young adult bulls which pay little attentions to each other but continuously skirmish with the harem bulls whose territories abut on the water. Occasionally they attempt to maintain territories in water one to two feet deep just off shore. In the more extensive rookeries there are a few passageways through the rookery which are not claimed by the harem bulls and over which the bachelors and females move to and from the water. These passages tend to form in the same general area each year. They are not incorporated in any permanently maintained territories because so many animals move along them that no stability is possible. In the smaller rookeries these passageways are not clearly defined, but the males whose territories are on the main routes of entrance and egress experience great difficulty in maintaining themselves and their harems.

This stereotyped pattern of distribution results primarily from the behavior of the males, but it has superimposed on it a complex distribution of cows and pups which results from the interactions of these two groups with the territorial and sexual interests of the adult bulls.

HAREM MAINTENANCE

The cows appear on the rookery in the middle of June after most of the bulls have already established their territories, and they continue to arrive during a period of more than six weeks. A mathematical analysis (Bartholomew and Hoel, 1953) based on marked individuals and daily censuses yielded the following parameters for the timing of the various activities of the cows: Interval between arrival on the rookery and parturition, two days; interval between parturition and estrus, six days; departure for sea, one day after onset of estrus; duration of first trip to sea, five days; duration of second and subsequent trips to sea, eight days; duration of stay ashore between trips to sea, two days or less. This complicated schedule of arrival and departure and changing reproductive status is further complicated by brief returns to the water caused by daily variations in weather. Thus, although the population of harem bulls is a stable, long-surviving social structure, the female population is in a continuous state of flux. At all times during the breeding season there are females in every stage of the reproductive cycle in the rookery. Further, the female population is continuously changing, not in absolute size but in composition. Females are incessantly going to sea to feed, returning to nurse their pups, or coming ashore to whelp. Out of this chaotic assemblage, the harem bulls form and maintain harems. Each harem represents a random sample of the female population as a whole, rather than a homogeneous group of females. Despite the variable nature of the population of breeding females, the behavior of individual cows follows a regular cycle and at all times in the cycle the cows have a basic uniformity of social response which allows the harem bulls to force onto the rookery as a whole a certain stability. However, the status maintained is not a static but a dynamic equilibrium.

The basis of the cow's social behavior is gregariousness. She is completely indifferent sexually to the male except during or immediately prior to the brief period of estrus. She shows maternal concern only for her own pup. Her small size with regard to the harem bull means that in all situations involving physical force, locomotor speed, and agility, the female is completely dominated by the bull. She can never successfully challenge the bull's dominance directly.

Organization of the female population. The organization of the female population into harems is the direct result of the male's strong territoriality and the indirect product of the female's gregariousness. When the pregnant females haul out on the rookery they join the groups of females already present. Consequently, the female population is at first concentrated near the edge of the water and gradually spreads inward as it increases. Thus, female location is determined not by proximity to a given male, or even by proximity to males in general, but by availability of space near other females. Mate selection *per se* does not exist. The tendency of the cows to form dense aggregations rather than to scatter widely over the rookery is reinforced, but not determined, by the behavior of the bulls. While his harem is small the harem bull greets each newly arrived pregnant cow with excited "woofs" and much shaking of the head from side to side. If the female shows signs of moving into an adjacent territory the bull blocks her way, pushes her back into his harem, or occasionally picks her up bodily in his teeth and carries or throws her back. Despite the temporary effectiveness of these maneuvers, a bull cannot force a female to stay in his territory, he can only delay her departure from it. As soon as the bull is occupied with another cow, or challenged by an adjacent harem bull, the cow waddles quickly to wherever she wants to go.

The dispersal of the females over the rookery is affected by several factors, of which the most important is the filling of the part of the rookery adjacent to the sea so that the newly arrived pregnant cows are forced to go inland. Terrestrial locomotion is relatively difficult for a pregnant cow. Once she settles down she may not move more than a few feet until her pup is born. Some aspects of the activities of the bulls also tend to disperse the newly arrived cows over the rookery. In a few days early in the breeding season, a bull occupying a favorably located territory may acquire a harem of a hundred or more females, not through any effort of his own, but because of the gregariousness of the cows (Bartholomew and Hoel, 1953). A bull which acquires such a large number of pregnant and pre-estrous females is behaviorally unequipped to maintain his harem as an intact social unit. If the females begin to overflow from his territory, his harem maintenance reaches a furious pitch. He charges along the boundaries of his territory, herding and crowding his cows toward its center, but his diligence is self-defeating. His actions crowd the females close together, and the crowding precipitates a continuous series of brief squabbles and fights which cause them to scatter. The scattering excites the bull, which herds them together again, and this initiates further dispersive aggressive activities between the cows. The net result is a noisy turmoil which stimulates the adjacent femaleless bulls to aggressive activity and, as discussed below, facilitates harem raids. Such situations repeatedly produced so much excitement that two, and sometimes three or four, idle bulls would simultaneously gallop to the edge of the overflowing harem, seize cows at random, and carry, herd, or toss them into their respective territories. In any given instance such raids are apt to be futile because the female, if she is the lone occupant of a territory, scurries over and joins some nearby group of cows at the first possible opportunity. However, if a bull can get three or four cows into his territory at the same time, their gregariousness is satisfied, and a relatively stable harem may be established. Thus as the season progresses the population of cows increases, extends inland, and is apportioned among the various harem bulls. In some areas on the rookeries the bulls which hold the more inland territories obtain no cows and remain "idle bulls." Once a bull has females in his territory, or the bulls adjacent to him hold females, territory maintenance becomes inextricably bound to harem maintenance and establishment. The bulls no longer compete for territory *per se,* but for females. They attempt to acquire cows at their neighbors' expense, and struggle mightily to prevent the departure of their own cows. Whenever for any reason a cow moves rapidly, a bull charges after her to turn her back into his harem. This response of the bulls to a rapidly moving female is so general that it often temporarily prevents a cow from retrieving a newborn pup that has wandered away or fallen off a ledge. Each time she starts after her bawling pup the bull charges over and forces her back.

If the females in a harem are crowded, they tend to scatter somewhat whenever the harem bull goes to sleep. On one occasion on July 5, all 20 of the bulls in the observation area were asleep simultaneously for about fifteen minutes. During this period the integrity of the various harems diminished perceptibly. A few restless females wandered freely from harem to harem. One cow, freshly arrived from the sea, wandered through five territories before finding a place and settling down. Since the females are completely nonterritorial, the social structure of the rookery is maintained only by the vigilance of the bulls. During the entire organized breeding season, their sleep consists only of brief intermittent naps. Heavy rain makes the females on the rookery restless and if it continues for several hours, many of the cows go to sea. The males are completely unable to stop such a group exodus because a bull can deal only with one cow at a time. The departure is contagious. First one female starts toward the water, then another follows, and another, and another, until a group of six or eight move in a loose group. The males through whose territories the females move, usually try desperately to detain them, but as soon as they stop one cow, another scurries past. Such local breakdowns of the social structure are only temporary, and because the female population is normally in a state of flux such group departures are relatively unimportant. Except for this group reaction to rain, the females almost never act on other than a individual basis.

Relation between principal responses of the harem bulls. The interdependence of territoriality and harem acquisition and maintenance was demonstrated many times daily during the breeding season. The sounds of a battle in one part of the rookery would alert males nearby to rush furiously around their territorial boundaries and herd all their females together; idle bulls, aroused by the sounds of battle, would dash to the nearest adjacent harem, seize a cow and drag or carry her into their female-less territory. Thus aggressive behavior in one area facilitated harem herding, harem raiding, and territory definition in adjacent areas, and caused a wave of activity to spread outward from the center of disturbance and sweep through the rookery.

The territorial, acquisitive, and copulatory interests of the harem bulls often compete with each other and this competition offers the opportunity of evaluating the relative strengths of the various drives. Whenever two bulls begin to fight in a congested area, the cows start to move away from commotion; as soon as the contesting bulls notice this they always rush back to round up their cows unless status as a harem master is at stake. The reluctance of the harem bulls to continue fighting when their cows begin to scatter is an important factor in allowing new bulls to establish territories for themselves. When the harem bull breaks off a fight and rushes furiously to herd up his females, the interloping male has opportunity to compose himself, prepare for the next onslaught, and generally consolidate his position.

While copulating, the bulls seem indifferent to either territoriality or harem maintenance. I have repeatedly seen a copulating bull watch without perceptible response, either vocal or otherwise, while another male captured several of his females. Since at the peak of the breeding season a harem bull copulates several times a day, and each coitus lasts five to seven minutes, in the aggregate these periods of suspended harem maintenance play a significant role in allowing harem recruitment by the idle bulls.

Variations in basic pattern of social structure. When the boundaries between adjacent territories are not defined by topographic barriers, the harems of adjacent bulls often become confluent, particularly when the cow population is at or near its maximum. The three largest harems in the central part of the observation area at Kitovi Amphitheater were confluent for an entire week in early July. There were so many females that the bulls could not patrol their territorial boundaries frequently enough or rapidly enough to keep their harems from mingling with almost complete freedom. During the first few days of this crowded condition, the males concerned tried repeatedly to maintain the integrity of their harems. They plowed along their boundaries forcing the females to move aside and clearing a swath four or five feet wide between adjacent harems. The cows withdrew indiscriminantly before the bulls, and females which had formerly been in one territory were often driven into another and vice versa. After the first few days the bulls gave up the effort, allowed the harem boundaries to disappear, and confined their herding to the edges of their harems which were still distinct. For several days these three males did not have separate harems. They merely maintained territories which were completely overrun with cows. Such a confluence of harems often develops in crowded areas. This breakdown of the social structure was primarily due to the extreme gregariousness of the females. While these three males had so many females that they could not maintain their harems, other bulls less than forty feet away had no females whatsoever. Because of the configuration of adjacent territories or because of topography, it occasionally happens that an area six or eight feet in diameter is not claimed by any male. The lack of disturbance in such unusual areas encourages cows and pups to accumulate in them and form relatively stable social units which are, in effect, ''bull-less'' harems. In the observation area the two bulls with the largest harems herded zealously when their territories were completely filled with females with the result that on July 4, fourteen females were pushed out into an area that was completely surrounded by established territories but unclaimed by any bull. Until July 11 this area remained unclaimed and held eight to twenty females. Aside from the absence of a bull, it looked like the other distinct harems in the area. As various of these unclaimed cows came into heat they wandered into the adjacent territories where they were copulated with. The factors holding the group together were primarily negative. The territory and harem maintenance of the bulls happened to isolate this unclaimed island and females and pups accumulated because of the absence of disturbances there. After the peak of the breeding season had passed, and the "bull-less" harem had dispersed, this unclaimed area was occupied by a pod of thirty to sixty pups which, like the cows, settled down in it because it was an oasis of relative quiet in the turmoil and confusion of the rookery.

Harem maintenance and sexual status of females. The cows are in estrus only for a few hours or at most for a day, and ordinarily they copulate but once (Bartholomew and Hoel, 1953). Consequently only a small percentage of the females on the rookery are of immediate copulatory interest to the bulls at any given time. Most of their efforts at harem maintenance are directed at pregnant females, pre-estrous females, or postestrous lactating females. The bulls recognize estrous females by olfaction, but their responses to females from the standpoint of harem maintenance are on the basis of vision and to them all females apparently look alike. As nearly as I could determine during weeks of observation, for purposes of harem maintenance the bulls react to all females identically regardless of their reproductive status and try to hold them all in their harems.

RELATION OF BULLS AND PUPS

Harem bulls are completely oblivious to the pups. When a harem bull sees another male about to raid his harem or to violate his territory, he charges directly at the source of his disturbance, plowing directly through and over his cows, stepping on the pups, rolling them over beneath his body, and knocking them through the air by the violent movements of his front flippers. These furious charges are repeated, often many times hourly, and each time it looks as if several of the pups will be mangled or killed. But, despite the pummeling, the trampling, and fierce blows the pups never seem to be injured, even when they are knocked six or eight feet through the air. I did not see a single instance where pups were injured by accidentally being run over or struck by the bulls. In part this was due to the durability of the pups, and in part to their active avoidance of the moving bulls. At any given time most of the nursing cows are at sea, and the pups are not confined to specific harems. They form aggregations (pup pods) in areas where activity is at a minimum. When a bull charges through one of these pup pods, the pups scatter like leaves before a wind. The bull cleaves a path through them, but he touches only a few.

In their frantic efforts to avoid the charging bulls, however, pups sometimes slip into crevices or run off the edge of a cliff. Occasionally, also, the accidental blow from the flipper of a bull may knock a pup off a cliff or into a crevice—this was noted several times on Kitovi—but on the whole the males despite their size and indifference are not a major source of pup mortality.

There is, however, one aspect of male activity which directly injures the pups. It was observed only four times, but three of the incidents were almost certainly fatal. When males are unusually excited aggressively or when two males threaten each other with particular violence, but for some reason are prevented from, or fail to fight, one of them will sometimes give vent to his frustrated aggressiveness by seizing any pup which happens to be directly in front of him, shaking it from side to side with frightful violence, and then tossing it wildly through the air. The pup may rise 15 or 20 feet vertically and sail through the air 45 or more feet horizontally, spinning wildly round and round. Three times I saw harem bulls toss pups over the edge of a cliff to their certain death. This tossing of pups appears to be one example among mammals of the "displacement" activity discussed by Tinbergen (1952).

BREAKUP OF SOCIAL STRUCTURE

In Kitovi amphitheater during the summer of 1951 the peak population of slightly over 400 females was reached toward the end of the first week in July and thereafter it fell off irregularly; the pup population reached its peak of almost 800 in the last week of July (Bartholomew and Hoel, 1953). By July 25 the intensity of harem maintenance by the bulls had begun to decrease and by July 27 there was an obvious decline in their aggressive behavior. By the end of July the harem bulls were gaunt caricatures of their former selves. Their outbursts of aggressive behavior were infrequent, and their sexual performance was relatively dilatory. By August 4 harem maintenance had ended and an organized social structure no longer existed.

The continuous days of observation carried out in the present study afforded opportunity to observe the actual act of territory abandonment in a number of harem bulls whose history had been followed throughout the breeding season. Departures were both spontaneous and forced. One example of each will be described because no documented observations on this subject have ever been published, nor have the factors leading up to the abandonment of a territory by a harem bull at the end of the breeding season ever been analyzed.

As the harem bulls became physically debilitated from their starvation and almost incessant activity, copulatory interest and vigor diminished, aggressiveness declined, and territoriality decreased. As a result, any new male so inclined could establish himself on the rookery. On July 31, a fat and fully mature male, which, judging from his well-fed appearance, has spent a good part of the breeding season in the water feeding, wandered into one of several abandoned territories in Kitovi Amphitheater. Three of the long-established harem bulls promptly began to trumpet the customary vocal challenge, which the new male as promptly reciprocated. When the new male reached the edge of one of the occupied territories, the harem bull which had been there continuously for more than a month, galloped belligerently to the attack. The new male refused to retreat and met the attack head on. The two animals seized each other and fought for six or eight seconds. Then the harem bull whirled and with obvious uneasiness dashed to the seaward edge of his territory where he paused for a minute or so, looking this way and that. Suddenly he charged through an adjacent territory, flung himself into the water, and drifted slowly out to sea. After successfully withstanding literally hundreds of attacks from scores of males, he had been induced to abandon his territory by a routine minor challenge.

Most of the harem bulls in the study area abandoned their territories spontaneously toward the end of the organized breeding season. Three such spontaneous departures were observed. With the gradual decline in numbers of cows on the rookery often a male would have no harem at all for a day at a time. At 8:40 a.m. on July 24 such a male, blind in one eye, which had had only two or three post-estrus cows in his harem for 36 hours, roused himself from a nap, walked leisurely over to the eight-foot ledge marking the seaward boundary of his territory, stood there for a minute, then suddenly slid over the ledge into the middle of the harem below, dashed directly through it causing a wild disturbance, scattering cows and pups right and left, and threw himself into the sea. He floated at the surface 50 to 100 feet offshore, getting rid of the filth accumulated during his stay ashore. He rolled over and over about his long axis, scrubbing his sides, belly, back, and flanks vigorously with his front flippers, and shaking his head. His washing turned the water around him brown. After he had been in the water about 12 minutes, another adult bull swam up to him and the two circled and dived together languidly without the least sign of aggressiveness. For the next several hours nothing was seen of this bull. At 2:43 p.m. I heard a vocal challenge and looked up to see the same one-eyed bull returning overland to his territory. He had apparently come ashore between Lukanin and Kitovi rookeries. He threatened the male who had been his neighbor for the preceding month, sniffed at the one female in his territory and settled down as if he had never been away. Two days later he returned to the sea and did not again come ashore before observations were ended on August 6. One other instance of a male abandoning his harem for a day toward the end of the organized breeding period was observed, but this returning is not typical.

As the social structure disintegrates, more and more young transient males wander through the rookery. Sometimes a harem bull that stays in his territory after he has ceased any but token harem maintenance will watch with apparent unconcern while a subadult male wanders through his area sniffing at the females scattered in it. These young males, although they have not participated in the organized breeding activities, play a significant role in fur seal reproduction, for they copulate with the late-arriving females that come into heat after the end of the organized breeding period.

Fur seals remain on the rookery well into the fall months (Kenyon and Willse, 1953), but there is no stable or formal organization after the first of August. Young nulliparous females ordinarily come ashore in August or later and it is probable that they are served by young bulls such as those mentioned above. During the latter part of the season these young subadult bulls can sometimes be seen on the rocks offshore copulating with small, presumably nulliparous cows, which have not yet come on the rookery.

DISCUSSIONS AND SUMMARY

The complex social structure of the Alaska fur seal depends on a variety of physiological and behavioral factors. The behavior patterns of the cow which importantly contribute to it are extreme gregariousness toward groups of cows, mild belligerence toward individual cows, lack of territoriality, indifference to bulls except during estrus, sexual acceptance of any male during estrus, and extreme sedentariness prior to estrus.

The behavior patterns of the bulls which contribute most importantly to social structure are highly developed territoriality in adults, poorly developed (or nonexistent) territoriality in subadults and young, acquisitive interest in all cows regardless of their reproductive condition, rapid acceptance of any established male, group aggression toward intruding males, and complete indifference to pups. These reactions interact to produce on the rookeries a definite and stable distribution in which the adult bulls hold territories near the shore, and the nonterritorial younger males either form a loose aggregation inland of the bulls or stay in the water.

The gregariousness of the cows, together with their sedentary nature prior to coming into heat, tends to distribute them in a dense, relatively uniform aggregation which at first occupies the parts of the rookery most accessible to the sea and then gradually moves inland as the number of cows increases. Their individual belligerence toward each other limits the density of their distribution. The rookery, however, prior to the arrival of the cows had already been divided into a series of stable territories by the aggressive activities of the bulls. The bulls herd the arriving cows into the centers of their respective territories and zealously attempt to keep them from scattering or joining other groups of the females. The result is that the cows are segregated into distinct, spatially segregated groups containing from two or three to over a hundred individuals. Under conditions of overcrowding the distinctness of adjacent harems tends to break down, but for the most part the diligence of the bulls imposes upon the whole rookery the characteristic social unit of bull plus harem. In their harem maintenance activities during the organized breeding period the harem bulls react in an identical manner to all females regardless of reproductive condition. Consequently, all females, pregnant, pre-estrous, and post-estrous, are incorporated into the social structure. This gives a stability which would not be obtained if the bulls tried to hold only females that were in estrus or approaching estrus. The primary concerns of the harem bulls—territoriality, harem maintenance, and copulation are mutually facilitating, but often compete with each other. When such a conflict of interests develops, harem maintenance takes precedence over territory defense, and copulation takes precedence over both of the others. This biologically reasonable priority of reaction is not universal among pinnipeds; for example, a male northern elephant seal will interrupt coitus to drive off another male (Bartholomew, 1952). This priority of reaction together with the considerable sexual capacity of the bulls assures reproductive efficiency for the species despite the extravagance of its social structure. Since the social structure is imposed by the bulls and the bulls are oblivious to the pups, the latter actually do not fit into the harem organization. They merely stay in the general area where they were born, spending their time in or near the territories of various males and tending to concentrate where conditions are the least disturbed.

Regardless of the fact that the social organization of the rookery is maintained only by the continuous diligence of the harem bulls, the largest harems develop in relative independence of the efforts of the bulls. Due to the gregariousness of the cows, a bull with a conveniently located territory may acquire in a few days 70 to 100 cows with less effort than a poorly located bull acquires five cows. The bulls that thus acquire very large harems bear a disproportionately large share of reproductive responsibility. The sexual capacity of the bulls is noteworthy. They methodically copulate with each of their females as the latter come into estrus. It is not unusual for a bull to serve four or five cows in as many hours. In one instance a bull which had been copulating regularly for many days served six females in five hours and 17 minutes and two of his services occurred within a period of 16 minutes. Nevertheless, it appears (Bartholomew and Hoel, 1953) that a bull cannot adequately serve a harem of more than a hundred cows, and toward the end of the organized breeding period the sexual capacity of the harem bulls as a group declines to a point where it is not quite adequate to accommodate all the cows which come into heat. This deficiency is apparently compensated for by the copulatory activities of the subadult males which become more and more conspicuous on the rookery as the social structure breaks up. Under most circumstances, however, a bull can serve as many cows as he can hold in his harem, for harems larger than 70 or 80 are unstable and tend to break up because of the squabbling of the females and the raiding activities of adjacent bulls.

Toward the end of July the social structure gradually disintegrates. Most of the seasons's pups have been born, few females are coming into estrus, and most important, there is a conspicuous diminution of vigor, aggressiveness, and sexual interest on the part of the harem bulls. After their long vigil of almost incessant activity, the harem bulls usually abandon their territories spontaneously or as the result of a trifling contest with some young bull which comes wandering through the rookery.

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DISCUSSION

DR. MCHUGH: I have always admired Dr. Bartholomew, because I knew he was one of the very few men alive who has ever attempted, and actually successfully taken the rectal temperature of an elephant seal; but I admire him even more now because I learned, in talking to him last night, that he had actually challenged the territory of a male fur seal, which is smaller and much more ferocious.

I am sure you have all been very interested in Dr. Bartholomew's paper. He has certainly done an interesting piece of work and I am sure you will have many questions to ask him. Please do not hesitate to ask, if you have any questions.

MR. HADLEY (Washington): What are the circumstances of the retirement of one of the masters of these harems?

DR. BARTHOLOMEW: The circumstances are almost uniform. The males do not eat or drink during their entire prolonged aggressive and sexual performance; so that, for slightly in excess of two months they do not have food. At the end of the breeding season they are completely exhausted physically; it is obvious from their performance and their appearance. Quite often they just pick up and leave, for no reason. One will be taking a little nap, charge up and off through the water, and leave.

Occasionally, one will just give a slight movement in the direction of a male—earlier the male would have charged over and chased him away—and that sort of chases the male away.

MR. LONGHURST (California): Would it be practical to install any physical barriers, such as concrete walls or anything of that nature, to try to limit the harem size to an ideal number?

MR. BARTHOLOMEW: In certain numbers, where the topography is extremely regular, that could be done. The exact effects one could only predict. In rough areas, topographic boundaries tend to determine territorial boundaries. However, specializations of that sort have been discussed informally at management and it was decided informally also that such steps are not at the present time in prospect. I do not know what their effect would be.

DR. MCHUGH: We learned a good deal more interesting information on the life and habits of the fur seal in talking to Dr. Bartholomew last night. I advise you to get together with him some time; I am sure you will learn many more interesting things.

MR. ELSER (Maryland): What is the ratio of newborn pups, males and females?

DR. BARTHOLOMEW: The sexual ratio is one to one. This means that, in any given year, only 39 of the 40 existing males—there is no additional mortality at sea as far as we know—are in excess.

MR. HUBBARD (Wisconsin): How does the female recognize her young when she comes ashore?

DR. BARTHOLOMEW: The natives and early workers on this group have all been convinced that the females did. When I arrived, I was not convinced; but, when marking females and pups I found to my surprise, and everybody else's gratification, that they did recognize them. As far as I can tell, it is by olfaction. The female goes sniffing around until she finds her own. The pups are not so discriminating; they will attempt to nurse any female which will let them.

DR. FRANK ASHBROOK (U. S. Fish and Wildlife Service): This is the first opportunity I have had to meet Dr. Bartholomew since he took on this most intensive and interesting study for the Service. I want to compliment him very highly on the splendid piece of research he has done. He has been very modest in telling you about it; but he never told you about the hardships he went through, sitting out there on these rookeries in the rain, fog, wind to get this data. It has been a most valuable contribution to this marine-mammal research. We appreciate it very highly.

MR. HESS (Maine): I was wondering if there were any other loss from predators among the seals?

DR. BARTHOLOMEW: There is no serious predation on the seals. They are at the end of the food chain. The only possible predator is the killer whale, and they are very rarely seen during the breeding season at the present time. In the middle twenties, there were reports of their presence. The hookworm disease is very serious. In 1951, 70,000 pups died of it. When they are three years old, the pups are worth a hundred dollars apiece, so that is a significant sum.

MR. HUNTER (Connecticut): I would like to ask Dr. Bartholomew how the pups withstand the long periods of the absence of the female?

DR. BARTHOLOMEW: That presents an extremely challenging physiological problem. They apparently store milk. Within a day they fill their stomachs up like inflated balloons; then, day by day, they digest a little of this. The first day after the female is gone, the pups are all blown up. Then, they get smaller and smaller; but, as their stomachs shrink, they put on bulk in their shoulders.

This would be a convenient and excellent animal for nutritional studies.

MR. HUNTER: One more question, Doctor. What is the age of the bachelor group?

DR. BARTHOLOMEW: The bachelors are from three to six years old. The harem bulls rarely are able to establish themselves before age nine; and, characteristically, the present work indicates that they are ten years old. They must continue to occupy this social status for eight years or ten.

The females breed at age four, and breed at least until age 15.

MR. ELSON: You told about these observations during the day. Does the same thing go on all night long too?

DR. BARTHOLOMEW: Yes, the extremely short Arctic night allowed me to be there all day and night, and I was unable to determine any diminution, day or night. So this activity goes on 24 hours a day, for six or eight weeks.

DR. ASHBROOK: Mr. Chairman, I might add that, since this has been brought up, with regard to the situation of hookworm infestation, we have been using the series of Dr. O. Wilfred Olson, at Colorado Agriculture Botanical College, for the last two seasons; and we have just completed negotiations for him to return and complete this study this coming season. So we will leave probably in May and be up there until the fall season.

DR. MCHUGH: Thank you, Bart, for a very interesting paper. I believe we have one more on the program this morning, and perhaps, since time is getting short, we had better carry on.

CHAIRMAN HUBBS: This last item on the program is another one in the series on marine mammals. It is on the Pacific walrus and its importance in the Eskimo economy. The paper was written by James W. Brooks, of the Cooperative Wildlife Research Unit, at College, Alaska. Due to his inability to be present, it will be read by John Buckley, also of Alaska.

THE PACIFIC WALRUS AND ITS IMPORTANCE TO THE ESKIMO ECONOMY[1]

JAMES W. BROOKS
University of Alaska, College, Alaska[2]

Few marine mammals have eluded the concentrated attention of biologists for so long a time as has the Pacific Walrus (*Odobenus divergens* Illiger). Occasional observations of the walrus have been made incidental to other studies, but the literature contains little specific information that could be applied to present-day management of this resource. In this matter, Collins (1939) published a commendable contribution, but his work was done prior to the vast expansion of the ivory carving industry that has occurred during the past decade. It is clear that Alaska's walrus population is now so important as a harvestable resource that the long prevailing *laissez faire* attitude toward the state of the animal's existence is not in keeping with the modern concept of conservation. Recognizing the essential and rather inviting need for a study of the walrus, the writer, in association with the Alaska Cooperative Wildlife Research Unit, initiated, in the spring of 1952, an investigation aimed at discovering the salient aspects of the walrus' biology, its population level and trend, and its present and possible future importance in the economy of Alaskan Eskimos. Field investigations were pursued from May through August in the Bering Strait and Wainwright-Point Barrow regions. This work will be continued during the spring and summer of 1953.

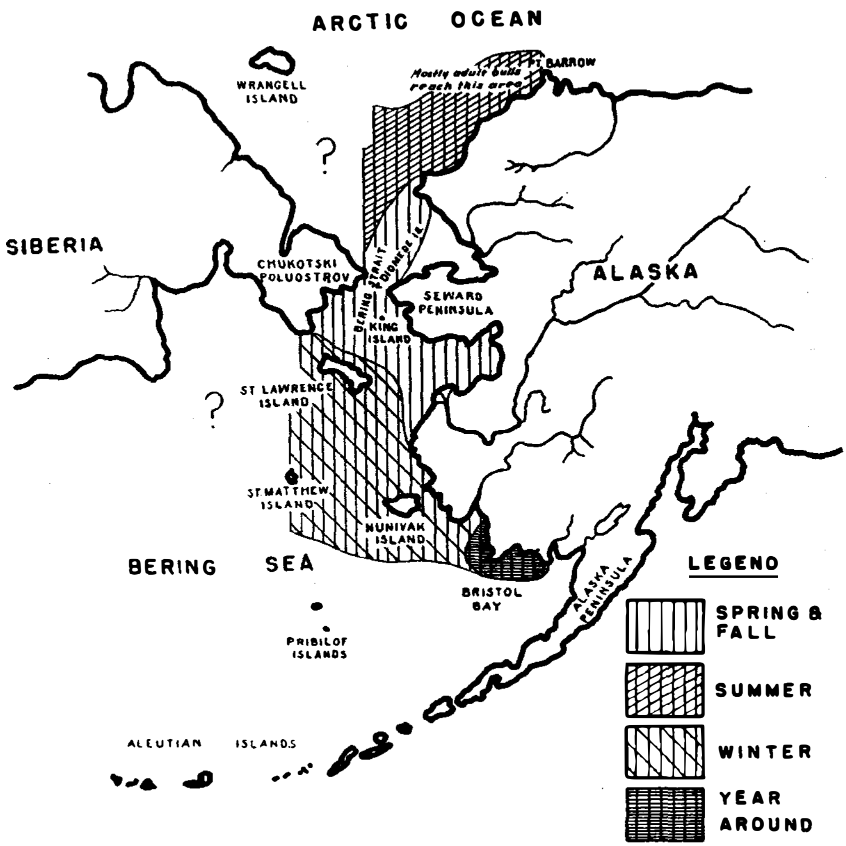
The inaccessible region in which the walrus occur has doubtlessly contributed to the neglect of this animal in the past, and it is hindering the present field investigations despite present transportation improvements.

Figure 1 shows the present range of the walrus on a seasonal basis. The animal's distribution west of the International Dateline, essentially a political barrier, is not known, though evidence indicates that Siberian waters are favored at least during the summer months. Herds of mature bull walrus spent the past summer in the Point Barrow region, but there were no indications of more than a few stray cows and young bulls anywhere along the Alaskan coast north of the Bering Straits after the last week of June.

Probably the most distinctive single feature of the walrus is its

[1]In the absence of the author, this paper was read by Dr. John Buckley, leader, Cooperative Wildlife Research Unit, College, Alaska.

[2]The writer is indebted to the Wildlife Management Institute and the American Museum of Natural History for the financial assistance that has made this research possible.



DISTRIBUTION OF THE PACIFIC WALRUS ON A SEASONAL BASIS

FIGURE 1

massive size, and this cannot be appreciated fully till one has been a party to pulling an animal out of the water and onto an ice floe. Two bulls were weighed by the writer: a four-year-old animal, 109 inches long (nose to tail), weighed 1,600 pounds; and an animal more than 15 years old, 144 inches long, weighed 2,795 pounds. Most of the blood was lost from these walrus before weighing, and the weights given do not compensate for this loss. Three adult cows averaged 101 inches in length and were estimated at 1,500 to 1,700 pounds. New-born calves weigh more than one hundred pounds.

The senses of the walrus are rather difficult to evaluate because the animals often fail to respond to rather strong stimuli. They do not appear able to recognize stationary boats or men at distances beyond 40 yards, though they sometimes show alarm at moving boats at distances beyond 100 yards. The aural acuity of the walrus is thought to be nearly equal to that of humans, though they completely ignore rifle shots as close as 100 yards to them if they are "hauled out" on ice floes. The cracking and grinding of ice may have accustomed the animals to similar noises. When possible, hunters approach walrus herds upwind, because they believe the animals will otherwise smell them and take alarm. The writer, however, has not had an opportunity to test this notion by deliberately presenting walrus with human scent.

Heinrich (1947) gives the following appropriate description of a walrus herd sleeping on an ice floe. "One member will always be awake and reared up, looking to right and left and sniffing the air. Then, secure in the knowledge that nothing is detectable within the range of his eyes, nose, or ears, he flops down to peaceful slumber, and by that time another rears up and takes a look. But they never seem to be aware of any danger until the shooting actually starts." Heinrich suggests, and is likely correct, that this action represents a behavior pattern developed early in the walrus' history when environmental conditions were somewhat different than those of today. Nevertheless, walrus in the water are extremely wary and frequently escape the best efforts of Eskimo hunters to dispatch them.

Walrus seem to have been harvested by the Eskimos of Alaska about as long as an Eskimo sea-hunting culture has existed. Middens of the Old Bering Sea and the Punuk Cultures abound with walrus ivory and bones. This Eskimo-walrus association has carried up to the present day. The extent of the walrus harvest in recent years is indicated in Table 1.

TABLE 1. APPROXIMATE TAKE OF WALRUS BY NATIVE VILLAGES
(Based on Alaska Native Service records and the writer's observations)

Place	Year	Population	Dogs	Walrus Killed
Barrow	1952	1,080	400	105
Diomede	1952	103	45	about 150
Gambell	1952	310	600	275
King Island	1952	160	80	over 100
Kipnuk	1950	184	225	about 4
Mekoryuk	1950	165	60	20
Nome	1952	about 200	250	11
Pt. Lay	1950	60	104	about 16
Savoonga	1948	240	500	about 185
Shaktoolik	1947	107	118	about 19
St. Michael	1952	166	109	11
Tanunuk	1949	100	125	10
Unalakleet	1952	438	600	10
Wainwright	1952	about 100	230	4
Wales	1952	160	35	42
Totals		8,773	3,481	962

These data are thought to represent near-average conditions through the last decade at least. Three thousand five hundred to 4,000 people with nearly an equal number of sled dogs utilize (with varying efficiency) 900 to 1,000 walrus annually. The villages of St. Lawrence Island, particularly Gambell and Savoonga, and the villages on King Island and Little Diomede Island are so dependent on the walrus for food and ivory that they probably could not exist without this resource unless substantial government assistance were provided.

Flesh, fat, skin, and viscera from walrus are used for human consumption, though much flesh and fat are also fed to sled dogs. As an item of human food, however, the ringed seal (*Phoca hispida*) outranks the walrus on a year-long basis because the seals are available in the winter, when walrus are notably scarce through most of their accessible range. Aside from food, walrus products have a variety of applications. Skins are used for covering boats and for making rope, intestines are made into rain parkas, bones are fashioned into harpoon heads and artifacts, and bacula sell readily to white visitors as curios. Then, of course, the ivory is the raw material for the important ivory carving industry of the Eskimo.

The wholesale value of carved ivory annually sold by the Alaska Native Service clearing house has ranged from $30,000 to $50,000 during the past few years; about $100,000 worth was sold in 1945. In addition, nearly equal quantities of ivory are sold directly to tourists or private retail outlets. The total retail value of carved ivory sold annually undoubtedly exceeds $150,000 and may approach $200,000.

The need for raw ivory by the Eskimos of the Bering Strait area encourages the killing of more walrus than can be fully utilized, and in Bristol Bay, a walrus herd that is believed to be nonmigratory has suffered serious reduction by Eskimos who do not themselves carve ivory or utilize the carcasses. As an estimate, probably 10 to 15 per cent of the total walrus harvest is not utilized beyond the ivory it affords. Fortunately, however, most raw ivory taken in Alaska finds its way to areas where carving is important. Jade from a recently developed deposit in the Kobuk River region has been supplied to the Little Diomede Eskimos, and it may partly replace ivory in the carving industry.

There appears to be little likelihood that the importance of walrus in the economy of Alaskan Eskimos will diminish in the immediate future. An increasing white population and tourist trade stimulates the demand for ivory curios, and the decline of reindeer production in the last decade is forcing more intensive pursuit of marine mammals for food purposes in some areas. Further enhancing this argument is the inertia of a long established sea-hunting culture.

In opposition to the aforementioned prediction is the force of increasing opportunities for employment (mostly seasonal) in mining, fishing, and defense activities being offered the Eskimos. One might also expect a decrease in living "off the country" as educational advancements reach these native people.

Of pressing moment now is knowledge of whether or not the walrus population can withstand the exploitation that it apparently must suffer. This consideration hinges chiefly on the current size of the walrus population and presents a problem that is seriously complicated by the international aspects of the animal's range. Some idea of abundance was gained during last summer's field work; between June 13 and June 18, the writer observed about 2,500 walrus passing northward within 10 miles of Cape Prince of Wales. During and preceding this same period, Little Diomede Eskimos reported very successful walrus hunting near their home island. Then in July and August, at least 600 adult bull walrus were observed or reported in the vicinity of Point Barrow. The consensus among older Eskimos is that the walrus have increased slightly, though steadily, from a low point in numbers that occurred about 1920.

Because of the difficulties attendant upon a direct count of the animals, it is thought that indirect indices offer the best means of assaying the walrus population. An attempt in this direction is being made by collecting walrus teeth, other than tusks, which are believed to be a reliable guide to age of the animals by virtue of laminated layers of cementum. However, a sufficiently large tooth sample has not yet been obtained to yield significant information on the walrus population structure.

Complete clarification of the walrus' breeding biology must await additional work, though certain aspects may now be stated with some confidence. The time of parturition is indicated by the fresh appearance of umbilical cords on calves observed in mid-June; these animals were undoubtedly less than one month old. The Eskimos of Wales and Little Diomede state that nearly all calves are born shortly before the walrus pass through the Bering Strait in June, and that females containing large fetuses are very rarely captured at this time. Since small embryos (23 and 17 millimeters) were taken from female walrus in mid-June and since segregation of the sexes was already occurring, breeding probably occurs in May or the first days of June. This supposition is further borne out by statements of the Eskimos that walrus copulation is observed infrequently in the Bering Strait, though the animals are much in evidence during June. From the foregoing, the gestation period of walrus appears to be a year, or nearly so, in duration. Rarely, calves may be born at other seasons

(Heinrich, 1947). Delayed implantation, if it occurs, must be of extremely short duration.

Examination of six reproductive tracts from parous females indicated, with one possible exception, that the animals did not bear calves in successive years. The questionable specimen contained an embryo and also a placental scar that was considerably smaller than other scars known to be only a few weeks old. In this case, the writer postulates an abortion or a winter birth, lethal to the calf, sufficiently early to permit readjustment to a normal estrous cycle before the time of regular breeding.

The minimum breeding age has not been determined by the writer, though Asdell (1946) gives it as four or five years for females and five or six years for males.

On the basis of this admittedly scant information, it appears that the reproductive capacity of the species is low. This is particularly important in view of the current demands on the walrus population by the Eskimos.

The predominant food items noted in walrus' stomachs both in the Bering Strait and Point Barrow area were molluscan forms, specimens of which are now in the process of being identified. The predominant food species, a bivalve mollusk, appeared to be similar in both areas.

Food availability probably has little influence on the summer distribution of mature bull walrus, which were noted to feed very little during July and August. The controlling factor in movements of bulls is almost certainly the location of the edge of the arctic ice pack. Cows and immature animals, on the other hand, probably are vitally dependent upon fertile feeding areas, though this statement is substantiated only by the word of Eskimos that cows and young walruses do contain food during the summer months while bulls usually do not.

Walrus were observed to feed in water ranging from 21 to 30 fathoms in depth. Since the entire range of the walrus is over the continental shelf, and therefore relatively shallow, it is believed that water depth influences walrus feeding chiefly through the agency of food species occurrence or abundance.

Hunting is believed to be the factor presently limiting the walrus population, and this appears to be a desirable situation if held within the productive ability of the animals. However, the harvesting of walrus entails a great deal of waste; in the writer's opinion, more walrus are killed and lost than are recovered. This situation stems from the unfortunate fact that nearly all adult bull walrus sink when killed in the water, at least during the spring and summer months. Under the same conditions, perhaps half of the adult cows and immature animals will sink. In addition, walrus are difficult to kill, and many mortally wounded animals escape the hunters to perish later. The writer has observed the killing of more than one hundred walrus, and in no instance was an attempt made to harpoon an animal before shooting it. If the Eskimos deliberately seek dangerous thrills, it is not in their walrus hunting!

The effects of disease and predation on the walrus herds are being investigated, but findings thus far indicate these factors to be of negligible importance.

The sole management or protective measure so far instituted is the Walrus Act of 1941, which prohibits the killing of walrus by persons other than aborigines, and the exportation of raw walrus products from Alaska. On the basis of knowledge thus far gained, it is not possible to state whether or not additional management measures are called for. However, on the assumption that some measure, such as regulation of kill, will prove necessary, the following suggestions may indicate usable approaches. To keep the walrus harvest within the productive capacity of the herds, a dependable index to the population trend must be developed. The index needed might well be obtained by requiring that a single tooth from each animal killed be presented to the managing biologist. Analysis of the population age structure on a year-to-year basis should reflect moderate population changes. The total kill is not considered a sufficiently sensitive index because a scarcity of animals could be concealed by extra hunting effort. Direct counting of walrus would be very expensive since multi-engine aircraft would have to be employed. Furthermore, it is doubtful if the results of such counts would be comparable on a year-to-year basis because of the many variables involved.

The enforcement of kill limits would initially require that an enforcement agent be stationed in each important village during the periods that walrus are taken. This action would demand the services of four or five men for a three- to five-week period during May and June, and one man for the remainder of the summer.

Development of more efficient killing techniques would greatly reduce the total kill without significantly reducing the harvest. An effective means of accomplishing such a change has not yet been formulated.

A reduction of the number of calves taken could also be a measure of great importance and practicality. Last spring, at least 96 calves were killed by the people of Gambell village alone (Fay, 1952).

The writer feels that the great potential value of the walrus as a game animal has been wrongly minimized by white people who consider their actions to be in the best interest of the Eskimos. Should a sportsman be permitted to kill a bull walrus while in company of

Eskimo guides, everyone might gain. The trophy would be carefully chosen and properly killed; the Eskimo would utilize the carcass and a nice check besides; the monetary value of a walrus might thus be multiplied several fold while the total number of animals killed could be reduced. The interest of sportsmen in a game animal is frequently excellent assurance that a species will not be unduly abused.

In summary, about 900 to 1,000 walrus are utilized annually by the Eskimos in Alaska. The ivory products from these animals are believed to have a retail value of more than $150,000. As an item of food, the walrus is of immense importance to the Eskimos.

Of the elements influencing the walrus population, hunting is manifestly the most important and is apparently the limiting factor.

Though the breeding biology of the walrus is incompletely known, it is believed that their fertility is quite low in relation to the hunting pressure. At the present time, however, the total walrus population appears to be of such size that there is little prospect that a dangerous reduction in numbers is imminent.

The role of food as an influence on movements is considered significant during the summer months only with respect to cows and immature animals.

Management of the walrus may be approached by several avenues, but positive action should await a better understanding of the population size and trend. Unfortunately, the international character of the animal's range introduces an element that could render the best measures ineffectual.

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1947. Unpublished observations of the Pacific Walrus near the Diomede Islands.

DISCUSSION

DR. MCHUGH: Thank you very much, Dr. Buckley, for reading this paper by Mr. Brooks. Are you prepared to answer questions?

DR. BUCKLEY: I will try.

DR. MCHUGH: If you have any questions, then, Dr. Buckley will do his best to answer them.

MR. BUTCHER: You mentioned the careful selection of trophies by sportsmen. Isn't that a dangerous thing anywhere, in any species of mammal especially? They always pick out the best, the prime, the finest one they can get. Isn't that going to cut down the finest breeding stock?

DR. BUCKLEY: That might possibly be true. I think there are several other things which enter in. The Eskimos, for the most part, take the same animals. They take the large animals for the ivory. They also prefer the ivory from the females. So I think you possibly, for the purpose of trophies, would take less mammals even though you took the best ones.

The other thing is that the area is relatively remote, and there would be very few people who had the financial wherewithal to engage in walrus hunting, were it legal.

MR. BUTCHER: Is there any place within the range where a sanctuary might be established? Or do they move around too much for that?

DR. BUCKLEY: The walrus move a matter of several hundred or perhaps thousands of miles in the course of a year. The one exception to that—and we are not even sure it is an exception, is apparently a nonmigratory herd in Bristol Bay. We hope to find out a good deal more about that particular herd this summer.

But, to answer your question, I do not believe so; and I do not think the walrus is in any great danger of extinction at the present time. I do not believe a refuge would be a wise method for preserving the walrus.

DR. MCHUGH: Are there any more questions?

I think this has been a very profitable morning. I am sure you have all enjoyed these papers, all of which have been of very high quality, I think; and I, for one, feel the morning has been well spent.

CHAIRMAN HUBBS: I wish to thank Dr. McHugh. I have known, for many years' experience when he was a student with us, that he always could be relied on to take an assignment and do it well. I am very grateful for the very capable way in which he has presented the discussion; and I think you all will agree that the discussions in this session have been very lively and very much to the point.

With this, we will call for adjournment.

TECHNICAL SESSIONS

Wednesday Morning—March 11

Chairman: PAUL F. HICKIE
Chief, Wildlife Investigations on Public Lands, U. S. Fish and Wildlife Service, Denver, Colorado

Discussion Leader: ANTON DE VOS
Biologist, Southern Research Station, Division of Fish and Wildlife, Department of Lands and Forests, Maple, Ontario, Canada

BIG-GAME AND FUR RESOURCES

INTRODUCTORY REMARKS

PAUL F. HICKIE

We are gathered here to talk about non-agricultural species. Big game and fur do not get along with plowed land and intensive farming, as do many of our small-game species. There has been a growing feeling among many of those working with big game that high populations, especially of deer and possibly of some of our other big-game species, are the result of mismanagement rather than management. The cutting, the burning, the lack of good forestry created range, and now that picture is changing. Many of you know areas which were formerly in low brush, where you could see to hunt deer, which have since grown up to heights of 20 or 30 feet, and the only place where you can do your deer hunting is along the road or some other fortuitous clearing.

I think it behooves the managers of big game to take consideration of what is going to happen in the future. If our game ranges are being perpetuated as the result of mismanagement which is being stopped, we need to think about what we are going to have in the future for some of our big-game and fur species. We need to think of them in the same category as some of our other natural resources, which we class as replaceable or irreplaceable. Many of these species are not irreplaceable in themselves; but they are irreplaceable because their ranges are gone. Never again will the bison be permitted to roam the vast areas which it roamed in the western United States; they do not get along with fences and with livestock and with the economy of the country.

Most of you attended the meeting yesterday afternoon, and I wish to call to your attention the fact that these species about which we are talking this morning are in the nature of second-class passengers, possibly even steerage passengers, on the good ship *Conservation*. The hand on the helm, which you heard voiced so many times, was "the greatest good for the greatest number." That does not mean big-game species or fur species; it means human beings.

The last point I wish to make is that, in order to maintain the proper place for many of these wildlife species in primitive areas, we need to have the facts immediately at hand; we cannot let our research on them get behind.

So, this morning, we have here further contributions toward this end, that we may know more about these species and how to manage them.

WOLVERINE, FISHER, AND MARTEN STUDIES IN A WILDERNESS REGION

HORACE F. QUICK

Department of Inland Fisheries and Game, Orono, Maine

In 1947 field work was begun on a fur resources survey in the region of Fort Nelson, British Columbia. Initial work was sponsored by the Arctic Institute of North America for the Office of Naval Research, and later phases were aided by the Wildlife Management Institute and the National Wildlife Federation. The project plan was to study natural resources in a primary stage of utilization and to investigate the biologic and economic phases of the local fur trade. It was also planned to make a study of rare species under wilderness conditions before conditions were so changed that such investigations might become impossible.

Fort Nelson is in northeastern British Columbia. The region served by this fur trade post is bounded on the east by Alberta, north by the Northwest Territories and on the west by the Liard River, near where it cuts the southeast corner of Yukon Territory. This post handles the trade from an area of about 20,000 square miles in the Liard drainage of the Mackenzie river system. A variety of valuable furs are produced here. It was for this reason that the area was selected for study. During the two years of field work trade in raw fur here amounted to nearly a half-million dollars.

It was hoped that the rarer animals could be studied in true wilderness habitat. The region was found to be in a transitory stage of resource utilization altered by intense trapping. Hence, population

Figure 1

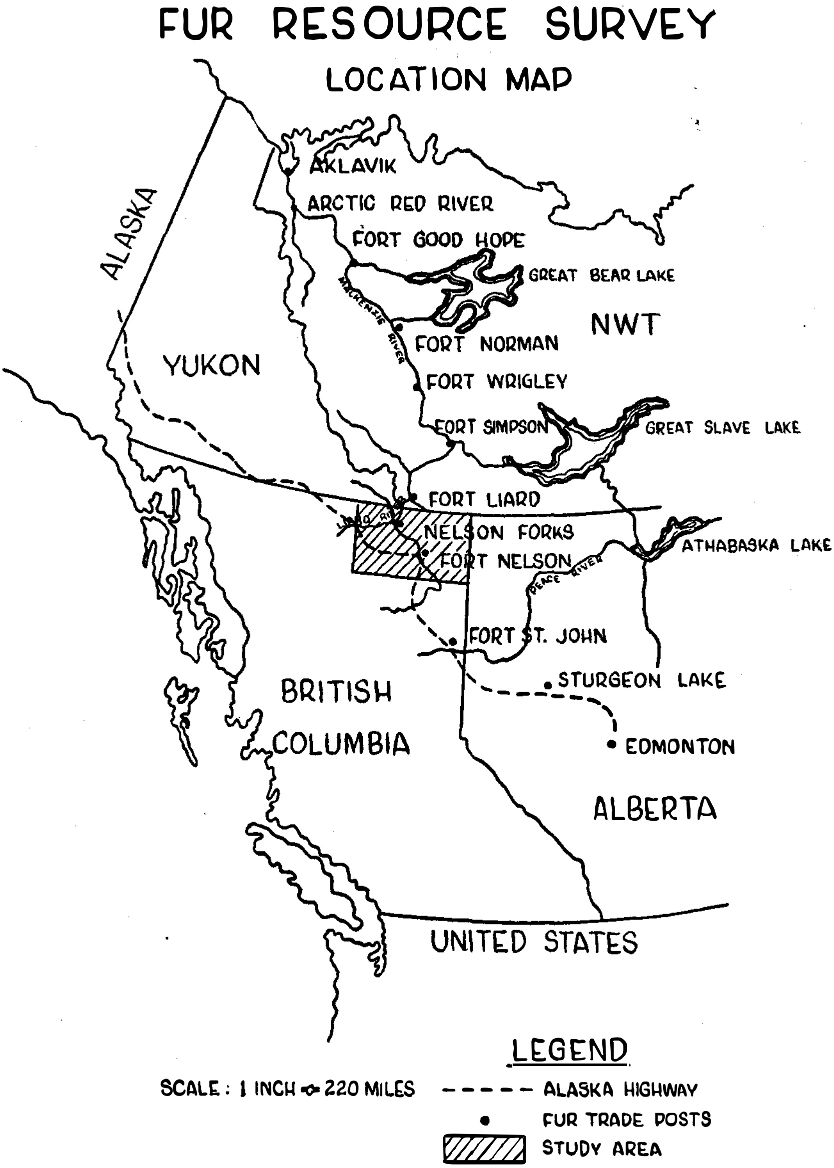
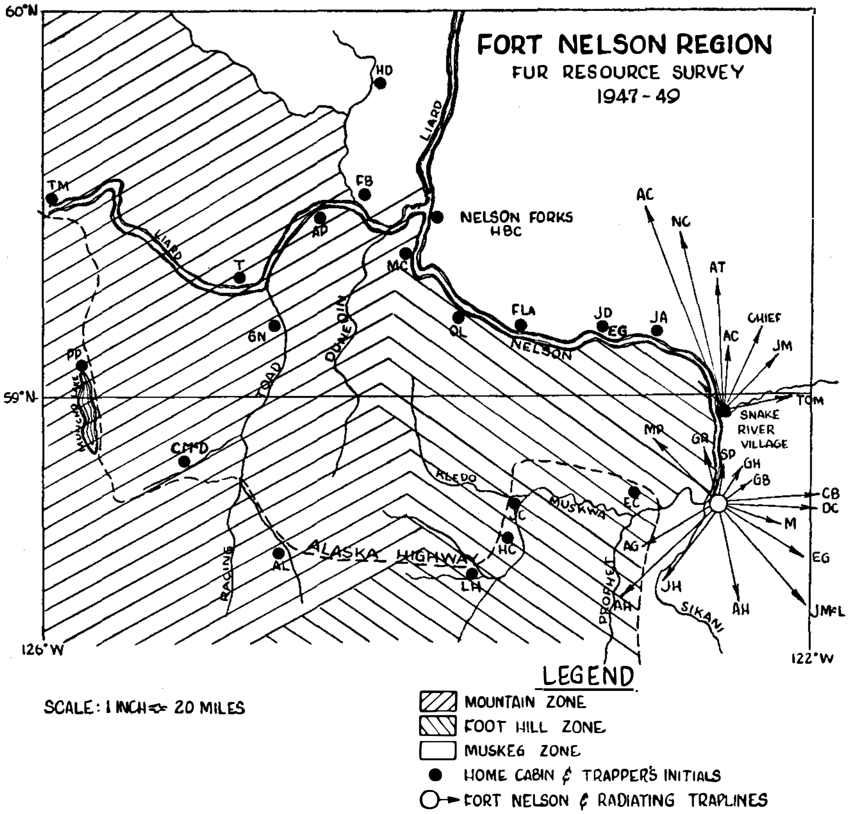

FUR RESOURCE SURVEY
LOCATION MAP
AKLAVIK
ARCTIC RED RIVER
FORT GOOD HOPE
GREAT BEAR LAKE
ALASKA
NWT
MACKENZIE RIVER
FORT NORMAN
YUKON
FORT WRIGLEY
FORT SIMPSON
GREAT SLAVE LAKE
FORT LIARD
NELSON FORKS
ATHABASKA LAKE
FORT NELSON
PEACE RIVER
FORT ST. JOHN
STURGEON LAKE
BRITISH
COLUMBIA
EDMONTON
ALBERTA
UNITED STATES
LEGEND
SCALE: 1 INCH = 220 MILES
ALASKA HIGHWAY
FUR TRADE POSTS
STUDY AREA

Figure 2



characteristics of the fur animals have been influenced by the fur trade. In times of economic stress, natives are forced to return to a subsistence economy characteristic of true wilderness. Some aspects of wilderness still prevail, but the region is not beyond the influence of civilization.

The dependent human population of the region consisted of about 200 people during the period of the study; a density of one person per 100 square miles. Metis are preponderant but full-blood Slavie Indians still outnumber resident white trappers, traders, police, and missionaries.

Ecologically, the region is in the Taiga Biome (Goode, 1943), chartecterized by spruce (*Picea mariana* and *P. canadensis*) forests, white birch (*Betula papyrifera*), and aspen (*Populus tremuloides*). Three physiographic subdivisions were recognized within the region. In order of area these are "muskeg," which is most extensive (Zach, 1950), "foothill" and "mountain." The area of the cover type units is small with a corresponding high degree of habitat interspersion.

Fort Nelson is within the zone of permafrost, having a mean annual temperature somewhat below freezing (Jenness, 1949). Winter temperatures have been officially recorded at minus 50° F., and summer temperatures may range above 90° F. during the long days of summer. Snowfall is moderate in the low sections but deep in the mountains. Total precipitation is approximately 18 inches a year. Since the region lies under snow for about half the year, most trapping operations are conducted by dog team. Prior to 1940 there were no roads in this region, but it is now bisected by the Alaska Highway.

Only certain phases of this survey can be reported within the scope of the paper. In general, the methods of study consisted of the collection of specimens, observations of animal habits, trapping techniques, and trading policies. Records of traders' and trappers' reports were compiled as close to the source as possible. About 2,000 miles of dog team travel during two winters permitted a survey of approximately 1,000 miles of trapline within the Fort Nelson region.

More than 2,000 miles of travel by pack horse and river boat in adjacent areas provided additional information related to the Fort Nelson fur trade. Economic and sociological information was obtained by traveling and working with Indian and white trappers. An extensive inquiry was made by personally questioning traders and trappers from Edmonton, Alberta, to Aklavik on the Mackenzie River delta. This is a distance of about 2,000 miles by road and river. Trading posts along these routes received the wolverine and fisher furs which are listed in Table 1.

POPULATION STUDIES

A calculated estimate of fur animal populations was based on track observations and catch records. The majority of animal trails crossed the traplines at right angles and thus could be counted while travel-

TABLE 1. REPORT OF FUR RECEIVED BY TRADERS—UPPER PEACE-LOWER MACKENZIE RIVER DISTRICT, 1947

Trading Post	Wolverine		Fisher	
Lesser Slave Lake, Alberta	0		0	
Sturgeon Lake, Alberta	0		0	
Fort St. John, B. C.	2		8	
Fort Nelson, B. C.	10[1]		18[1]	
Fort Liard, NWT	8		4	
Fort Wrigley, NWT	2		0	
Fort Good Hope, NWT	0	Tracks reported	0	No tracks seen
Arctic Red River, NWT	0	Tracks reported	0	No tracks seen
Aklavik, NWT	0	No tracks seen	0	No tracks seen

[1]Traders' records and known kill differ. (Company and free traders reports combined.)

ling with trappers. From this observation a hypothesis was postulated that the frequency of animal tracks intersecting a random cruise line was proportional to the population.

It was also thought that by comparing observations of cruising habits with counts of trail intersections, a population estimate could be calculated. The principal involved is similar to that used in making censuses of small mammals (MacLulich, 1951). Considering the size of the area under study these seemed to be the most practical means of estimating populations.

In the region served by the trading post of Fort Nelson there are about 2,500 miles of trapline. During 1947[1] a calculated 1,114 miles of these traplines were surveyed by dog team. The tracks of wolverine and fisher which crossed the lines were recorded (Table 2). Weather conditions and other factors greatly influence the chance of seeing tracks but this is unavoidable in extensive field work.

TABLE 2. FREQUENCY OF TRAIL OBSERVATIONS

	Crossings observed on 1,114 miles of line: 1947	Crossings reported from 2,500 miles of line: 1947	1948
Wolverine	15	15	10
Fisher	5	16	6

WOLVERINE (*Gulo luscus luscus* LINNAEUS)

Distribution: Records obtained directly from the traders (Table 1) are an indication of the density distribution of wolverine and fisher. From these, Fort Nelson appears to be a center of wolverine population in western Canada. Trapping intensities, of course, influence catches, but in the case of the wolverine, trapping intensity is more directly related to population density than it is in a consideration of other species. This is partly because of the destructive characteristic of the wolverine and partly because market value does not materially affect trapping intensity. Wolverine tracks were reported on every trapline in 1947. All three zones (muskeg, foothill, and mountain) appeared to be equally inhabited by wolverine. The decline in the reported frequency of wolverine and fisher trails in 1948 (Table 2) seems to be reflected by the smaller kills of that year (Table 3).

Winter travel habits: Track studies indicated that wolverines usually travel alone, at least during the winter. Trails in mud and sand were found during the summer also, which appeared to have been made by animals travelling alone. Several tracks of this type were

[1]Hereafter, 1947 refers to the trapping season of November, 1947 through February, 1948; 1948 refers to the trapping season of November 1948 through February 1949.

TABLE 3. WOLVERINE TRAP RECORDS

1947-48				1948-49			
	Killed		Escaped		Killed		Escaped
JC	3	JC	4	TM	2		
Michel	1	Mi	1	Arch.	1	Arch.	1
EdG	1	St	1	JMc	3	JMc	3
Narc.	1	Ac	1	JC	3	JC	3
Fontas	1	JMc	1	St	1		
Alec T	1	AH	1	Carn.	1		
Ole L	4			JH	1	JH	1
Lorne	1						
LaRoche	2						
	15		9		12		8

seen in Mt. McKinley National Park, Alaska, and these tend to indicate a solitary nature even in the summer. Occasionally paired trails were seen especially in early winter. In numerous cases, reported and observed, wolverines passed traps where others had been recently killed. This might indicate the use of favored travel routes, probably of family groups. Three wolverine trails on three separate streams were each followed for about two miles directly down the stream courses. One trail was followed along the edge of the Alaska Highway for nearly two miles at which point it led into the dense bush. Wolverine trails sometimes follow the dog trails. Their tracks have been followed meandering back and forth across the trapline for distances of eight miles in one case and ten miles in another. In general this species seems to follow the "line of least resistance" as do some other large predators. Animals caught in traps seem to travel a straight course as if with a destination in mind. They frequently stop to fight the trap and often escape (Table 3). Wolverine are usually alive if they are found in the trap. However, two small animals were found dead in traps during a period of cold weather (42 below zero F.). In a compilation of the number of wolverine trapped, one finds that a large proportion escape. Table 3 illustrates the reports directly from the trappers.

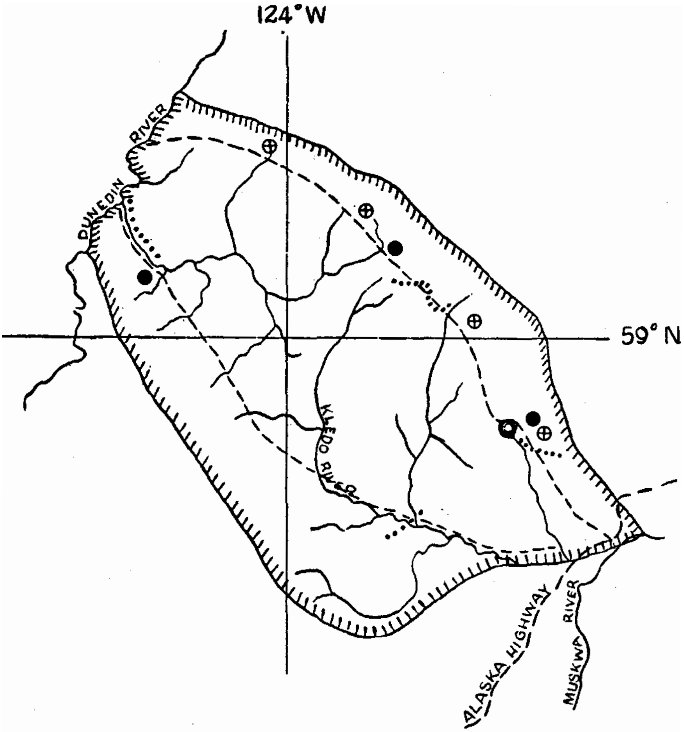
Wolverine were not known to escape from the trap without leaving one or more toes in it. Thus, figures for 1947-48 account for nine trap-marked wolverine which escaped during this season, and 15 unmarked wolverine which were killed. The following season, 11 unmarked and one trap-marked wolverine were known to have been killed. In addition to these, eight were reported to have escaped, all of which left toes in the traps. This type of information aids in making an estimate of population.

After the "winter fur" trapping season closes the beaver hunt begins. Travel by dog team is generally good, and there is opportunity to estimate residual populations by track studies. Observations of this

FIGURE 3

REGISTERED TRAP LINE OF JOHN CALLISON

FORT NELSON, B.C.



SCALE: 1 INCH = 8 MILES

LEGEND

- APPROX. BOUNDARY
- APPROX. ROUTE OF TRAPLINE
- WOLVERINE KILLED 1947
- WOLVERINE ESCAPED 1947
- WOLVERINE TRAILS

nature were made on three traplines totaling about 900 square miles. The smallest of these, Michel Parsons', was most accessible and thus studied more carefully. Post-season track counts produced good evidence of three wolverine ranging this 100-square-mile area. In the following fall Parsons independently reported that three wolverine were cruising his area. One animal had been killed during the preceding season; thus a minimum of four animals ranged this and an adjacent area in the fall of 1947. The area of the two traplines combined was computed as 324 square miles. A density calculated from these figures would be one wolverine to 81 square miles.

The largest area of about 600 square miles had been trapped for the previous 13 years by a very diligent and reliable white trapper, John Callison. He has kept accurate records of his catches. During 1947 he killed three wolverine and lost four. That year I made a late season trip with him. The circuit is figured conservatively at 140 miles. It requires seven days of travel by dog team to circle the line. Residual population estimates of wolverine were made by track counts. The number of separate wolverine trails counted agrees with the known number of wolverine trapped but escaped this season, namely four. Therefore a minimum of seven animals ranged this area prior to the trapping season of 1947; the density can be calculated at about one animal to 85 square miles. In combined area the three traplines constitute a block of about 900 square miles, over which at least 11 wolverine roamed. A density calculated from these figures would be one wolverine to 81 square miles.

A clue to populations would be information on the extent of travel or cruising radius that the individual animals undertook. I was unable to completely follow out any wolverine track. However, some indication of the extent of wolverine movements has been obtained from reports noting frequency of wolverine trail intersections with traplines and by a few records of animals which were retrapped or shot. A summary of these trappers' reports indicated that the animals are likely to roam a maximum distance of about 20 miles in any given direction, after which they generally return to former haunts. Observations, made personally, however, indicate that 10 miles is a more probable average range. If half of this is used as a hypothetical cruising radius, the area ranged by an individual wolverine would be about 80 square miles.

Wolverine density estimates based on catch records and residual track counts from two areas separately, were one animal to 85 square miles and one animal to 81 square miles. A range based on cruising radius observations was about 80 square miles an animal. These estimates are complementary. If these calculations can be accepted as a preliminary estimate of wolverine densities, it might be concluded that the species attained a population of about 250 wolverine in the region, during the pre-trapping season of 1947.

Analysis of catch records. The catch record of wolverine from John Callison's trapline for a period of several years is given in Table 4. During these years, this trapper has operated his line in a consistent manner. None of the wolverine killed by this trapper during the last two seasons indicated were sold. Many trappers keep wolverine furs for trimming their moccasins and parkas. This practice accounts for the difference between the numbers of furs marketed and the numbers known to have been killed. At least two factors influence biological interpretations of wolverine catch records. One, the proportion of animals trapped which escape, and the other, proportion of animals trapped which reach the market and thereby establish a written record.

TABLE 4. WOLVERINE CATCH RECORD: JOHN CALLISON'S LINE

Season	Killed	Escaped
1944	2	No data
1945	0	4
1946	1	No data
1947	3	4
1948	3	8

Sex ratios. The collection of wolverine specimens represented about 50 per cent and 75 per cent, respectively, of the total known kill of wolverines for the years 1947 and 1948. Sex ratios of the kill for these two years show a slight majority of males. Significance is uncertain because of the numerically few data. Nevertheless, the ratios are comparable to those obtained from more numerous data on related forms, a discussion of which will follow later. It is believed that a greater number of specimens would indicate a more balanced sex ratio.

Weights and physical measurements. Maximum weights of male wolverine were about 25 pounds, and females were weighed at 12 pounds. Maximum total lengths of wolverines collected were 41 inches for males and 36 inches for females.

General habits. Enough observations were made during the period to substantiate some of the legendary stories about the "Injun devil."

TABLE 5. SEX RATIO OF WOLVERINE

	Total kill	Total collected	Male	Female	Sex ratio
1947	15	7	4	3	1.3 to 1
1948	12	8	5	3	1.6 to 1

Perhaps these can best be summarized by translating the Cree and Slavie names for this animal. In Cree, the wolverine is called "kee-quahageese," and in Slavie, "nowah." Both words mean "a tough thing" or as one Slavie put it while tracking a wolverine in a trap—"one tough bugger." Food and foraging habits observed indicate that the wolverine is more of a scavenger than a killer. It follows skillful hunters like lynx, wolf and man.

Economic Status.

Fur value:

Catch records for the wolverine differ more from market records than any of the other fur species traded into this post. Natives prize the skin for trimming garments and usually they will not sell them. One-third of the known catch of wolverines was not entered on the fur trade records of this region in 1947.

It was a practice of trading companies to buy skins where available and trade them into Eskimo country where they are in high demand. Traders paid about $12.00 per pelt in Fort Nelson during 1947. Raw wolverine pelts were sold by traders to Eskimos on the Mackenzie delta for about $65.00. One trader at Aklavik whom I interrogated was saving all the pelts which could be obtained for sale to the U. S. Government. I examined the pelts of six wolverine cubs which were said to have come from Siberia *via* fur buyers in New York City. This seems to illustrate the vagary of the fur trade. Pelts shipped from New York City to the arctic for sale to Eskimos were being recalled by fur buyers for sale to governmental agencies, presumably at prices higher than Eskimos were willing to pay. The source of these particular wolverine furs raises other questions. It is likely that the economic margin between the import price of this peltry and the sale price to Eskimos signifies biologic as well as economic conditions. I have learned from Swedish and Finnish biologists that wolverines are well known to them in their respective countries. Wolverine populations in these countries seem to be greater than in American arctic and subarctic regions but we do not have sufficient quantitative data from either continent for comparison.

In Fort Nelson, ten skins which were marketed in 1947 for about $150 represented only a little more than one-tenth of one per cent of the total value of fur production. Even if all of the wolverine pelts taken in this region had been marketed, the gross value of this peltry would not have exceeded one per cent of the total fur trade of the region.

Damages:

The aggregate loss of furs in the Fort Nelson region during 1947-48 as a result of wolverine depredation was less than that caused by wolves. The following list (Table 6) is the best information I could obtain; some of the cases were observed.

TABLE 6. FURS DAMAGED BY WOLVERINE

1947	1948
3 squirrels lost	1 mink destroyed
1 marten damaged	10 (approx.) squirrels lost
1 fisher lost	3 rabbits lost
	4 marten lost
	1 marten damaged
Approx. value—$150.00	Approx. value—$125.00

John Callison reports that in 1940 a wolverine repeatedly ran a ten-mile stretch of his line and destroyed 13 furs of various species. Trappers frequently skin animals on the line and discard the carcasses. This tends to reduce damage to furs. A lynx alive in a trap can fend off the wolverine but when dead, the wolverine will ruin the hide in order to eat the lynx. Occasionally, smaller fur animals are carried off and cached by wolverines. Trappers sometimes are able to recover the cached pelts by trailing the thieves. The wolf also will do this. It should be pointed out that in some years shrews cause more damage than either wolves or wolverines. Shrews will burrow into the body of a dead animal and live on its flesh. On several occasions I have seen shrews jump out of the body cavities of dead marten as the fur animals were removed from traps. Trappers report that during some years damages are serious. Pelts that I examined during 1947 were reduced in value 20 to 30 per cent by shrew damage. In 1948 no damage of this sort was observed and it was believed that the ensuing "mouse year" might have reduced shrew-damage to furs by its "buffer" effect.

Numerous other damages attributable to wolverine constitute a financial loss and inconvenience to trappers. Panniers and dog harnesses are occasionally destroyed. Food supplies and meat caches upon which trappers depend are sometimes carried off, or rendered useless.

Summary of economic status:

Since this species probably never attains a dense population level, and the fur is usually not of high value, it does not constitute an important part of the fur resource of this region.

Damages caused by wolverine often exceed market values derived from the sale of pelts. Except for the occasional high percentage mark-up which traders sometimes obtain, the species is unimportant in the fur trade.

FISHER (*Martes pennanti pennanti* ERXLEBEN)

Distribution. The fisher seems to have been more abundant around Fort Nelson than in the other regions of the upper Peace River and the Mackenzie River district which are listed in Table 1. It does not appear to range as far north as the wolverine. Loucheux Indians between Arctic Red River and Aklavik apparently have no name for the fisher which suggests that it is not known in the region of the lower Mackenzie. The Fort Nelson-Fort Liard area appears to be at the periphery of fisher range in North America and it might be suspected that populations would not reach high densities here.

Catch records from within the Fort Nelson area show that fisher were most numerous in the mountain section. A larger proportion of the trappers in this zone caught fisher and their individual catches were larger than those in other zones as well. Records from individual traplines which are designated in Table 7 by the initials of the trappers might be said to illustrate either fisher distribution or trapping intensity. It is true that some variation in trapper efficiency is involved in these records but even so the average catch per trapper in the mountain zone was distinctly greater than in the other zones.

TABLE 7. FISHER CATCH BY ZONES
(successful trappers only)
1947

Mountain zone		Foothill zone		Muskeg zone	
TM	3	LH	1	EnG	1
MC	4	JH	1	GB	1
AP	5	OL	2	Mike	1
Tib	1	VK	1	Fontas	1
CMcD	1	AH	2	JMc	1
Total	14	Total	7	Total	5

(summary: all trappers)

	Total number trappers in zone	Total catch in zone	Average catch per trapper
Mountain	8	14	1.75
Foothill	14	7	0.50
Muskeg	14	5	0.35

FREQUENCY OF FISHER CATCH PER TRAPLINE MILE
(approximate summary of data)

Trapper	Area square miles	Line miles	Fisher catch	Line miles per fisher
TM	600	140	3	47
AP	700	100	5	20
MC	700	100	4	25
OL	400	60	2	30
JC	640	140	2	70
LH	600	100	1	100
JH	220	40	1	40
EnG	300	70	1	70
GB	200	80	1	80

The catch records of two white trappers present an interesting comparison of fisher distribution, by period as well as by location. Tom Mould, in the mountain zone (Liard River Crossing) and John Callison in the foothill zone gave reports as listed in Table 8.

In 1944 Mould set out to rid his line of fisher, claiming that they damaged marten furs and also killed marten. He assiduously built dead-falls because traps did not always hold fisher. According to the record it appears that he was successful. (Ironically, fresh fisher trails were seen at his home cabin on Liard River in 1948.) Mould has usually killed more fisher than any other trapper in the region. His area is very mountainous. The catch record of John Callison, from the foothills zone, is considerably different even though the two men are equally efficient and energetic trappers. They operate lines of comparable length.

The records of trappers from the mountainous region generally always include fisher in the catch. Those in the foothills usually catch one or two each year but rarely more. Trappers in the muskeg country catch fisher rather infrequently. Nevertheless, fisher tracks were observed on all traplines. Notwithstanding the fact that Mould made special effort to remove fisher from his area, the evidence indicates that fisher were more numerous in the mountainous parts of this region.

Range and population patterns. The numbers of fisher trails which I observed in 1947 were mostly in muskeg and foothill country where fisher populations appeared to be least dense. Trappers reported nearly equal numbers of wolverine and fisher crossings in 1947, and this suggests equal populations of these two species in the region as a whole. There is a possibility, of course, of mistaking marten tracks for those of fisher. However, there was a low incidence of overlap in the sizes of the feet of fisher and marten specimens from this region.

Catch records and other observations show that the radius of movement of fisher in Ontario given by deVos (1951) is about the same as that observed in the Fort Nelson region. One female fisher collected at Fort Nelson had been trapped previously and had lost three toes

TABLE 8. FIVE YEAR COMPARISON OF FISHER CATCH RECORDS

Year	Number trapped by Tom Mould	Number trapped by John Callison
1944	23	1
1945	9	1
1946	no record	1
1947	3	0
1948	2	2

from the left front foot. It was retrapped by the hind foot in February about five miles from the site where first trapped. One trapper caught two fisher within ten miles of line within a two-months period. Actual tracking has shown that fisher will travel a minimum of eight or ten miles in one trip but such travels were boxed within an area two by four miles in dimension. These were not completely traced out but were believed to be a close approximation of the area ranged by the particular fisher which made the tracks.

Within a large area inhabited by fisher two patterns of distribution can be observed in winter. Single trails are most common, but at times trails are found which show that more than one fisher has traveled the same route. Tracks of two fishers along the same route appeared to have been made at about the same time and it is presumed that the animals were traveling together.

Trappers report that some traps repeatedly catch fisher, and marten, too, while other sets never make catches. They refer to such trap locations as "lucky sets" and might take three or four animals at one station in the same year. From this type of information it is obvious that several animals use the same travel routes, but of course, it does not prove if the animals were traveling together or not. Evidence of the use of the same travel routes by a number of individuals suggests family group ranging habits. Young animals probably continue to follow the mother even into the winter, but one might expect a rapacious species to eventually develop an intolerance to others of its kind, at least during the winter season when food is difficult to find.

The majority of evidence indicates that fishers are solitary during the winter period and this characterizes the winter distribution pattern of the species. Distribution patterns, however, will naturally be governed by population level and by prey densities. They should be expected to vary in time and locality.

During 1947, 26 fishers were known to have been killed in the region. This closely agrees with the catch of 24 wolverine (of which nine escaped) and suggests that the pattern of trap distribution along 2,500 miles of trapline was equally effective in sampling the population. As pointed out previously, trail crossings of these two species were equal, also. Even though the distribution pattern of fisher seemed uneven, that is, more dense in mountainous sections, the populations of fisher and wolverine in the Fort Nelson region seemed to be roughly equivalent. If this were the case as it appeared to be, and individual range requirements of fisher are only half (cruising radius of five miles) that of wolverine, there must have been considerable area not occupied by fisher. There seems to be no doubt that the muskeg areas were only sparsely frequented by this species.

Although much area was unoccupied by fisher a further refinement of density distribution based on the foregoing data is not practical. As a matter of record it seems permissible to prorate the average density to the area as a whole. A density estimate prior to the trapping season of 1947 based on track and catch reports was one fisher to 80 square miles. The population of the region probably was about 250 animals in the fall of 1947.

Sex ratios. The number of fisher examined in 1947 represents about 66 per cent of the total known kill from the region. Sex ratios of fisher trapped in the Fort Nelson area (Table 9) are reasonably similar to those observed by deVos in Ontario and reported by Coulter from Maine (deVos, 1951). All of these data represent studies from 1947 through 1950. It should be observed that these data are samples from extreme localities within the range of fisher.

TABLE 9. SEX RATIO OF FISHER EXAMINED
Fort Nelson, B. C.

Season	Male	Female	Total	Ratio
1947	5	12	17	1 to 2.4
1948	3	5	8	1 to 1.6

Nothing was detected to indicate that sex-selective harvesting might have occurred in the Fort Nelson region. In early season catches sex ratios are usually unbalanced, males being more numerous. As trapping pressure increases or is prolonged, the sex ratios tend to balance or show a predominance of females. There is a close agreement in the pattern of these data on fisher and similar data on marten. A larger sample could be expected to show a more closely balanced sex ratio as it did in deVos' work. It is difficult to decide if this characteristic is applicable to the whole population but it probably represents it more accurately.

General habits. Stomach and scat analyses agree quite closely with food habits data reported by deVos. Hunting trails indicate that grouse and red squirrel are sought as well as snowshoe hare. Probably the majority of squirrels are killed in burrows rather than in trees as fisher travel mostly on the ground. Several specimens had shrew remains in the stomachs. Porcupine hair and quills occurred in about 30 per cent of the specimens. The tracks and signs of struggle were seen where a fisher tackled a porcupine, first in a tree, then on the snow, killed it and carried it off.

Economic status. The numbers of fisher marketed in this region never are significantly high. To the majority of trappers the fisher represents only an incidental income, and none of them count on fisher pelts as a dependable source of revenue. When fisher prices are high, one of two pelts will yield a high proportional return. As is well known to the fur trade, the price of fisher pelts probably fluctuates more than that of any other fur. In 1947 the top price paid for finest female fisher in this area was $125. The following season, the same grade of pelt brought, grudgingly, from the trader, $30.00. Male fisher, less valuable than female were accepted only as a token against debts owed by trappers.

Except for the claim of one trapper, mentioned previously, no observations or records were obtained to indicate that the fisher causes any economic loss to the trapping enterprise.

Only 18 pelts were known to have been sold at this post during 1947. Access over the Alcan Highway has changed the trading characteristics of the region, and the balance of the catch probably was sold at other posts. Pelts sold at an average of $75 in 1947. A gross return of approximately $1,500 was calculated by two traders individually. This represents about ten times the value of wolverine furs traded here. In the aggregate, the fisher returns were about 0.75 per cent of the total value of all furs sold as Fort Nelson. Pelts traded elsewhere, of course, yielded an income to the trappers but this was not recorded in the local trade.

Fisher are similar to wolverine in one fur trade characteristic, but different in another. Biologically, the fisher and wolverine apparently do not reach population levels high enough to allow these peltries to contribute materially to gross income in this region. Economically, fisher peltries fluctuate much more than wolverine peltries and sometimes bring considerable profit to individual trappers. Fisher furs, however, do not make a consistent contribution to the fur trade of this region.

MARTEN (*Martes americana americana* OSGOOD)

Field work on this project produced a collection of 250 marten skeletons which have been cataloged by the University of Michigan Museum of Zoology. It represents 16.5 per cent of the known catch of marten for two consecutive years from an area of about 20,000 square miles.

Sex ratios. Yeager and deVos have reported on the unbalanced sex ratio of the marten catch. Yeager has shown that males are taken more frequently in the early part of the season and that this provides a means of regulating the kill so that females can be reserved. He has shown that regardless of season, the total kill averaged a larger proportion of males (61.6 per cent).

Table 10 lists some data which partly support these views but also

TABLE 10. MARTEN CATCHES AND SEX RATIOS
1948 November-December Catches

Trapper	Total	Male	Female	Ratio
JA	18	15	3	5 to 1
SRB	21	17	4	4 to 1
Total	39	32	7	4.5 to 1
Per cent		82.1	17.9	
1948 November-February Catches				
AP	29	8	21	1 to 2.6
JC	46	19	27	1 to 1.4
LC	52	26	26	1 to 1
SGG	24	12	12	1 to 1
MP	12	6	6	1 to 1
Total	163	71	92	1 to 1.3
Per cent		43.5	56.5	
Specimen Collection				
1947	127	64	63	1 to 1
1948	123	67	56	1.2 to 1
Total	250	131	119	1.1 to 1
Per cent		52.4	47.6	

allows further speculation. The first section showing early season catches illustrates that a preponderance of males are taken in November and December (4.5 to 1 or 82.1 per cent males). In contrast, the second section shows the total catches of several trappers for the entire season, November through February. Here a distinct shift of sex ratio through the balance point to the preponderance of females (1 to 1.3 or only 43.5 per cent males) is notable. Indian and white trappers are represented in this group but all are hunters who trap the full season or work the line intensively.

The third section of this table probably represents the most practical analysis of the matter. It illustrates the average influence of trapping pressure on a marten population over an extensive area for a period of two years. The data represents about 16 per cent of the total kill and is drawn from the whole region and from all classes of trappers. Here it is shown that males are preponderant but to a minor degree (1.1 to 1 or 52.4 per cent males).

It appears then, that the sex ratio of the kill is a function of trapping pressure as has been stated by Yeager (1950). However, the sex ratio of the kill does not necessarily represent the true biological characteristic of the population. In a number of references the preponderance of males in mustelid populations has been described as characteristic. It seems probable from this study that females might sometimes outnumber males in an actual mustelid population. The trends of sex ratio data in three species of mustelids suggest that optimum utilization is obtained when the sex ratio of the catch approaches balance. A preponderance of males might indicate underutilization and of females, overutilization of the resource.

Distribution and popuation. Marten populations were more dense in 1947 than any other fur species except red squirrel and beaver. The distribution pattern of marten conformed closely to the timbered zones. In general, the muskeg zones were uninhabited during 1947. In the following year more marten sign was seen in muskegs than previously. Track records as well as catch records show that certain habitats were frequented and that several individuals used the same travel routes. These variables make calculations of population density very difficult.

Table 11 lists the catches per linear mile of trapline on three registered areas. While this does not accurately demonstrate density or distribution it does furnish a clue to productivity. A summary of reliable data from 12 traplines is as follows: 344 marten taken on 802 miles of line or an average of one marten per 2.32 miles. About one marten to two miles of line represents the annual kill rate or productivity for 1947 and 1948.

TABLE 11. A COMPARISON OF MARTEN CATCHES ON THREE TRAPLINES
(Complete records directly from the trappers)

Trapper	Area square miles	Line miles	Ratio line to area	Number traps (approx.)	Catch 1946	Catch 1947	Catch 1948
Indian	68	40	1.7	200	40	21	20
White	365	100	3.7	400	100	48	52
White	610	140	4.3	500	115	65	46
Average catch per mile of line					1.1	0.55	0.49

Probably the best means of determining the base population of marten would be by estimate of the residual population after the trapping season. This should be done during the period of lowest density prior to birth of the next generation. It would be necessary to consider the effects of trapping when determining areas to be sampled. Whereas the populations along winter traplines would have been altered, areas unaltered in population characteristics would be accessible over sled trails used during the beaver hunt in early spring. Accessibility within this region is a major obstacle to investigation.

Economic status of marten. Winter trapping activities during 1947 produced about 750 marten and nearly the same quantity in 1948. The value of the catch in 1947 was approximately 15 per cent ($27,-500) of the gross income ($206,000). This species was the most important terrestrial fur animal and was regarded as the staple trade item during the winter. Beaver fur, by contrast, represented more than 80 per cent of the total value of furs produced in the region. Biological interpretation of traders' records;

Damage by predators sometimes reaches a proportion which distorts the biological interpretation of fur trade records. In 1947 one-third of the marten killed on Parsons' trapline did not reach the market because of wolf and wolverine depredation. This is an extreme case, but it emphasizes that there is sometimes a great difference between the biological facts and facts apparent from the records. Three fisher were reported destroyed by wolves out of a total known kill of 26. Thus, a high percentile error can be encountered at the primary source of data. An incident is known in which seven red fox were discarded in one day on the same trapline because the pelts were "rubbed" and consequently not marketable. This, of course, is unwise management but nevertheless a factor which should be considered in the biological interpretation of traders' records.

SUMMARY

1. Wolverine populations appeared to be equally distributed over the region; density was calculated at about one wolverine to 80 square miles; the population was computed at 250 animals in the fall of 1947.

2. Wolverine furs are not important in the fur trade of this region; they constitute only about one-tenth of one per cent of the total value of trade.

3. Fisher populations were not uniformly distributed in the region but were concentrated in the mountain zone. However, all zones had a representative population. The regional population as well as the catch was comparable in numbers to wolverine numbers.

4. Fisher furs are not important in the fur trade of this region; they contributed only about three-quarters of one per cent of the total trade.

5. Marten populations were distributed throughout the region, but muskegs were generally unoccupied. Densities were not computed because of variables which were difficult to evaluate; yield per linear mile of trapline was computed at one marten to two miles of line. As judged by the sex ratio of the catch, this constitutes marginal utilization of the resource.

6. Marten were the most valuable terrestrial fur animals, yielding about 15 per cent of the gross production.

7. Sex ratios of trapped marten do not always illustrate the actual characteristics of the population.

8. Traders' records did not fully express the population characteristics of the fauna.

9. Existing trapping pressure does not endanger the wolverine population. "Educated escapees" constitute a residual population capable of perpetuating the present density.

10. Wolverine and fisher catches removed only about 10 per cent of the estimated total population.

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DISCUSSION

DR. DEVOS: Mr. Chairman, ladies and gentlemen: It is a pleasure for me to be able to direct the questions of this morning's session; and I hope there will be an active discussion from the floor, because we have several excellent papers on the program.

I know that some of the topics which are discussed this morning are not too familiar to the majority of the audience; but please do not hesitate to ask questions, even if it is a bit outside your particular field.

I certainly was personally very interested in the information which Mr. Quick presented on the wolverine. The wolverine is a species which has been poorly written upon in the literature; and it is a species which is gradually going downhill in large parts of Canada particularly, but also, I understand, in some parts of Alaska. Any information which can be gathered about this species is certainly a contribution.

MR. PRESNALL (Washington, D. C.): Last fall I noticed, in the Southern Yukon territory, a number of wolverines being live-trapped for use in zoos. I was wondering whether Mr. Quick had any information on a similar type of trapping around Fort Nelson.

MR. QUICK: There is nothing of this sort in the Fort Nelson region. For one reason, I did not want to upset the natural way the trappers approach their job, or the registered trapline system; I wanted to see the full effect of their operations, you see, so I did not initiate any program of that sort.

MR. PRESNALL: I thought perhaps there might have been some such activity by independent trappers.

DR. R. E. TRIPPENSEE (University of Massachusetts): Did you get any inkling of the apparent reason for thin populations?

MR. QUICK: I did not have anything to compare wolverine or any of the populations for that region, having never seen the region before; so I do not know what the relative status of these species is. I hope to get back on that region and be able to make further appraisals of densities for comparison.

DR. TRIPPENSEE: Would you care to volunteer a guess as to whether that is a saturation situation or a carrying capacity phenomenon?

MR. QUICK: I will risk it.

It seems to me that probably wolverine populations are denser somewhere in some regions out in the Alaskan peninsula. I base this only on letters from friends; but I do believe there are denser wolverine populations, and we know there are much denser fisher populations, for that matter, right in the State of Maine, at the moment, than there were in Fort Nelson.

As far as martens are concerned, it seemed to me that possibly it was a center of marten density.

DR. JOHN BUCKLEY (University of Alaska): Do you have any information on breeding of wolverines in these 15 carcasses you were able to collect?

MR. QUICK: No, I do not. The reproductive tract I collected from these specimens and put into solution, the solution froze when the temperature got around 52 below zero, and I lost all my specimens.

DR. DEVOS: I am afraid that time is catching up with us. I just want to remind you that Mr. Quick's information about the range of wolverine from eight to ten miles fits in pretty well with range computations which have been made for marten and fisher, as far as the size of the animal is concerned. I would also like to draw your attention to the fact that, in Mr. Quick's opinion, the fisher does not appear in muskegs. This same phenonemon is found to be true in the case of marten and fisher in Ontario; and that obviously produces the over-all capacity of northern areas for these species.

It was also of particular interest to me that Mr. Quick verifies findings made by others that, in the catch, the female fisher is higher than the male; and, as you may know, that is the other way around in the case of martens. This particular phenomenon, in my opinion, requires much more detailed study.

Finally, his findings that the sex ratio of marten killed is dependent on the duration of the trapping period verifies findings by others.

Thank you, Mr. Chairman.

CHAIRMAN HICKIE: May I see the hands of those who have ever seen a fisher out in the wild? Some of us hope to some day.

It is not often, in a big game session, that you have a chance to talk about a Hollywood star; but this next subject—no doubt, the majority of you have seen *Beaver Valley.*

At previous times, the beaver played a very important part in adding to income of many of our pioneers. At the present time, its status is very controversial. Usually, it is managed because it gives trouble somewhere, and not because it is regarded as a real natural resource of the land; yet, its role in watershed management may be extremely important.

A PRELIMINARY REPORT ON INTENSIVE BEAVER MANAGEMENT

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Most present-day beaver management is extensive management. It consists of state-wide or county-wide restriction of seasonal take, trapping seasons, and trapping technique. Such measures maintain the beaver population of a region by limiting the harvest to insure a residual breeding stock in the region.

The present high beaver populations of many areas are the direct result of the extensive clear cutting of timber and the widespread forest fires which were characteristic in the northern forests until recent years. Modern forest fire control and intensive forest management practices are gradually reducing the areas of suitable beaver habitat. The beaver is adapted to the early stages of forest succession, especially the post-fire types which include aspen and willow. It is reasonable to predict that beaver populations in managed forests will be sharply reduced when the forest is maintained in a constant cover of climax tree species.

Extensive beaver management does not consider the ecological relation of beavers to their environment. It merely limits the harvest by restrictive control of the activities of beaver trappers. Under such a system of management some beaver colonies are trapped out and much beaver food may be wasted before the site is reoccupied. Other beaver colonies in the same region may remain untrapped and surplus beavers may migrate to areas where they are a nuisance problem. The current concern with the problems of flooding of valuable timber, invasion of trout streams, and damage to crops and orchards is an indication that extensive management is not a completely satisfactory beaver management method.

Intensive beaver management, by contrast, requires a thorough knowledge of the ecology of forest succession and of beaver population dynamics. Under intensive management, high beaver productivity is sustained by the maintenance of early stages of forest succession. All surplus beavers are harvested, thus maintaining a balance between the residual population and its food supply. The harvest of all surplus animals also prevents them from stocking other areas where they may be unwanted. In other words, intensive beaver management strives to increase the beaver population by improving site conditions, thereby increasing the number of harvestable surplus animals at each colony site.

Before intensive beaver management can be undertaken, it is necessary to inventory the areas available for such management. The land must first be classified to determine what resource can best be produced on a given site. Under some conditions beavers are not compatible with other forms of land use. Some sites are best used in the production of timber or agricultural crops, while others may best be used for trout production. In still other areas, beavers are the preferred crop. It is for the land manager to decide at which sites beavers can best be produced.

The possibilites of intensive beaver management are being investigated on the 15,000-acre Huntington Wildlife Forest, a property of the State University of New York, College of Forestry (King, R. T., *et al.*, 1941). The Forest is typical of Adirondack Mountain areas to which intensive beaver management may be applied. This area includes 32 beaver colony sites, 27 of which are believed to be best adapted to beaver production. The five remaining sites are best adapted to spruce pulp production.

SITE MANAGEMENT

Before intensive beaver management measures could be formulated, it was necessary to inventory the 27 colony sites to determine the beaver conditions at each site. The first step in this inventory was to determine the ecological status of the beaver food supply. It was found that the colony sites could be grouped in four "site types" on the basis of similarity of ecological conditions: Northern-hardwood, Bracken, Marsh, and Hardwood-conifer. Each of these site types represents a different problem in the maintenance of a sustained yield of beavers.

The northern-hardwood colony sites contain abundant beaver food trees, but the trees are too large for the beavers to utilize them efficiently. In addition, the more tolerant beech, birch, and maple are crowding out the old and overmature aspen. Optimum conditions are being replaced or succeeded by conditions unfavorable to beavers.

In contrast, colony sites in the bracken site type present an entirely different food problem. Bracken sites were intensively burned over around 1900. Aspen and high beaver populations followed the fire. The beavers have now logged off the available aspen, and bracken fern has become dominant at the sites. The fern is preventing regeneration of more aspen trees, and most of the bracken sites have now been abandoned. The beaver manager must restore the food supply at these sites if beavers are ever to return.

Colony sites in the marsh site type are the most dependable beaver producers on the forest. The marshes contain an abundance of alder, willow, and red-osier dogwood. However, due to the flat terrain of marshes, beaver impoundments "drown" the available food supply. After short periods of abandonment, the foods regenerate, and beavers reoccupy the marsh sites.

Hardwood-conifer sites complete the various site type categories. At these sites spruce, balsam, and cedar are crowding out the beaver foods. Also, beavers are reluctant to pass through the fringes of conifers to obtain hardwoods which may lie beyond them. Thus, the problem at hardwood-conifer sites is mainly one of availability.

These are the general problems which face the beaver manager of a typical Adirondack forest. Similar problems are characteristic of forested areas in other regions. The ecological conditions which prevail at each site type suggest possible improvement measures which might be employed. These possibilities are also being investigated on the Huntington Wildlife Forest.

Bracken and marsh sites generally require some form of beaver food establishment. In these cases, the beaver manager must hasten natural succession, and establish foods which best meet the needs of each colony. For example, foods for marsh sites must be resistant to flooding. On the other hand, foods for bracken sites must be resistant to dry conditions. All beaver foods should sprout vigorously after they have been cut.

Food establishment measures may take the form of seed bed preparation, sprout encouragement, seedling planting, or the planting of cuttings. Seed bed preparation and sprout encouragement involve such techniques as burning, scarifying, disking, use of weedkillers, etc. Thus far, these techniques have shown little promise on the Forest. While good food establishment results have been produced by planting seedlings, the procedure is slow and expensive. The most promising method thus far found for food tree establishment is the planting of cuttings. The method is unusually fast and economical, and involves planting cuttings of willow, striped maple, and dogwood in the soil adjacent to beaver flows.

Forest succession has already replaced optimum beaver conditions at hardwood-conifer and northern-hardwood sites. Therefore, succession must be "set back" in these areas. Several clearings have been created on the Huntington Forest, and some of these clearings now contain excellent stands of aspen, a favorite beaver food. Thus, forest clearings represent an environmental improvement measure which may be employed at northern-hardwood and hardwood-conifer sites.

POPULATION MANAGEMENT

Colony site improvement is but one phase of intensive beaver management. In addition, the beaver population at each site must be managed to remove surplus animals and maintain a balance between the beavers and their food supply. The beaver population of each colony site on the Forest was determined with a fair degree of accuracy by live-trapping, food storage surveys, and observations of beaver activities. These censuses indicated that there are several types of beaver colony composition at the 16 active colony sites. Some sites support only one or two beavers, either adults or yearlings, which may not reproduce for several years. A few colony sites contain two adults and three or four kits, suggesting either a recently established population or one in which reproduction has been interrupted. The remainder of the active colony sites support a full population consisting of two adults, three or four yearlings, and three or four kits. At these colonies the yearlings leave the site just before the birth of the next year's young. These yearlings are surplus animals, which represent the profit from intensive beaver management. Their capture prevents the stocking of other areas where they may be unwanted, and yet does not interfere with the parent colony's production.

The problem of selectively trapping surplus yearling beavers is also being investigated on the Forest. The harvest of adult animals stops colony production for several years. The harvest of kits is a wasteful procedure, since the animals' pelts will nearly double in value in just one more year. Therefore, it is essential that only the surplus yearling animals be taken. Thus far, live-trapping has been used exclusively for selective harvest on the Forest. This method of harvest is both time-consuming and expensive, but further study may reveal more efficient selective harvest methods.

SUMMARY

Present-day beaver management is extensive management. It consists largely of restrictive control of beaver harvest, thus maintaining a regional breeding stock. Extensive management will not continue to maintain satisfactory beaver populations in forest areas because of the development of selective logging methods and improved forest fire control. The beaver is adapted to early stages of forest succession and will be eliminated from many areas when the forest is maintained in climax vegetation.

In intensive beaver management suitable stages of forest succession are maintained at individual colony sites. Several site types are recognized, and the colony sites in each of these categories require a different form of management. At bracken and marsh sites some form of beaver food establishment is necessary to hasten the progress of succession toward favorable beaver habitat. At northern-hardwood and hardwood-conifer sites suitable beaver habitat has been replaced by climax vegetation, and forest succession must be set back. These various colony site improvement measures result in high beaver populations, and it is necessary to harvest all surplus animals from improved sites to maintain a balance between the beavers and their food supply. This harvest, in addition to providing saleable pelts, prevents emigration into areas where farm crops, timber, or trout are the preferred form of land use.

Intensive beaver management is still in the experimental stage and additional research and experience are required to make it effective.

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DISCUSSION

DR. DEVOS: Thank you, Mr. Patric.

I regret that Mr. Patric's paper is presented when beaver prices are reaching a low ebb. If his paper had been presented, let us say, ten years ago, we could have had a lot more efficient use of his recommendations.

However, as fur prices are right now, it seems rather difficult, under the present management schemes which exist, actually to put into practice his recommendations.

One thing which I might bring to your attention is that, in Canada especially, the sale of beaver meat is increasing very rapidly. Beaver meat is being sold in food markets and all places in the north country more and more; and people have acquired quite a liking for it. There is no reason whatsoever in the world why beaver could not be just as acceptable to the general public as, for instance, muskrats are. Meat is certainly quite profitable, and I would not hesitate for a moment to live on beaver meat for the whole winter. Are there any questions or comments from the floor?

MR. ADAMS (Michigan): I might refer for a moment to the paper of Mr. Quick which preceded this.

We had quite a time out in Ann Arbor a couple of months ago, persuading the men of the Walton Club and, also, the Varsity M Club, that they should not try to get another wolverine down from Alaska as a mascot for the football team.

The Forest Service policy in the western upper peninsula, where I have been concerned with beaver management, is one of regarding the aspen as a weed tree; and they are doing quite a bit there in the way of coniferous plantings to bring back a pine stock which originally covered that area. We feel that perhaps the peak in the beaver population in the northern Lake States has been reached, and that numbers may well be on the decline even now.

The problem of beaver food establishment, which Mr. Patric mentioned, in intensive management of this animal, would be, you might say, at odds with the Forest Service program of planting conifers in the northern Lake State area.

Several of us who have been working in that part of the United States have long realized the need for a study on fern ecology, which is something which is not necessarily in the domain of wildlife management, but is something, I believe, which the foresters themselves would be interested in, as well as, should we say, pure botanists.

Another thing which Mr. Patric remarked on was the fact that the beavers would not go back through conifers to get aspen and other foods. Several of the beaver ponds in the northern upper peninsula of Michigan are bordered with balsam, which has now reached more than an understory stage below the aspen, which the beavers are cutting; and they create some awful tangles under such conditions.

DR. DEVOS: Any other comments?

DR. PETRIDES (Michigan): I wonder if the speaker will comment at least on generalizations regarding the cost of such a program, relative to the profits, as he put it, of the same program?

MR. PATRIC: Since our program is still in the experimental stage, we realize that, as in most forms of research, we are losing money. But the fact of the matter is that we feel, under such a system, the benefits of controlling beavers is also a factor which can be considered as profit; in other words, if we can keep beaver out of the areas where we do not want them, if we can prevent them from doing this damage for which they are infamous in spruce regions, and so on, we feel that also is profit.

Of course, right now, we realize too that the worth of the beaver pelt is pretty low, probably around twelve dollars at the present time; but we still think the possibility for this form of management is good.

DR. O'ROKE (University of Michgan): Is there not still a place for extensive beaver management as a part of multiple forest-land use?

MR. PATRIC: There certainly is. We feel that extensive management will always be necessary, but that intensive management can be applied over and above extensive management.

MR. NORMAN G. BENSON (Michigan): I am wondering whether there is any work done in experimenting with the new hybrid poplars and the possibility of this food for beaver management.

MR. PATRIC: We have tried the establishment of some of the hybrid poplar under limited conditions; and, thus far, we have had no luck at all with them under Adirondack conditions.

DR. DEVOS: In closing this discussion, I might mention that we are very much afraid that, with the present low level of prices, we will get such increases in populations that we may get such things as tularemia outbreaks. Several outbreaks of tularemia have been described in the last four or five years, in parts of Eastern Canada and, also, adjoining Minnesota. If and when disease occurs, if we are not prepared to go into the bush and harvest the beaver satisfactorily, these outbreaks may reoccur on an even larger scale.

PROGRESS IN THE MANAGEMENT OF THE MOOSE OF SOUTH CENTRAL ALASKA[1]

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Alaska is presently enjoying a period of relative abundance of moose adjacent to areas of highest human population. As a moose kill puts an average of five hundred pounds of prime meat in the locker, it is a much sought prize for hunters.[2] Since moose cannot exist in as high densities as some of the other big game animals, it is obvious that our moose herds cannot withstand a hunting pressure that could be easily supported by a deer herd. The value of this food and trophy animal is such that measures must be taken which will result in a maximum harvest over a long period of time. Although considerable work has been done on this animal, the Alaskan moose investigations have not progressed to the point where management measures are well defined enroute to indefinitely sustained hunting season. Investigational methods and resultant data obtained so far in the Alaskan moose studies are presented in this paper for evaluation and use by others concerned with moose management.

IMPORTANT SOUTH CENTRAL ALASKAN RANGES

Kenai Peninsula. — A 9,192-square mile area (exclusive of major lakes) the Kenai Peninsula is mountainous in the eastern part, a glaciated lowland in the western third. Roughly one-half of the area is moose habitat of varied quality. The range has supported a high population for 40 years with irruptions at various intervals. A present kill of from 300 to 500 bulls is sustained annually. In general, moose populations have been on the downgrade for a period of about 25 years, due largely to the progress of succession on winter ranges. A series of mild winters and improved range conditions have resulted in a minor population upswing the past four years on the west side of

[1]Joint contribution of Alaska Federal Aid Project 3-R and the Kenai National Moose Range.
[2]Locker plant records of number of pounds of meat from 170 moose in storage.

the Peninsula. A 290,000-acre burn in 1947 is relieving the winter forage situation. The Peninsula now has wintering areas aggregating 800 square miles capable of supporting more than two moose per square mile. Half of this is within the 1947 burn. Of the remainder, 150 square miles exists in natural wintering areas such as stream drainages, flood plains, timberline areas, and flats below receding glaciers. Approximately 250 square miles persist in a dwindling remnant of fire-created ranges responsible for the peak moose populations of the early 1920's. The Kenai National Moose Range, established by Executive Order in 1941, occupies 2 million acres on the west side of the Peninsula. Here the management of moose is given priority. The Range will continue to furnish public hunting, fishing, and recreation in an area being subjected to increasing settlement.

Susitna Valley. — The Susitna River, together with the Copper River, drains the greatest portion of south-central Alaska south of the Alaska Range. The river has its source in the Alaska Range, flows south and west through the Talkeetna mountains, and enters the broad Susitna Valley, where the important moose ranges are located.

The Susitna Valley covers an area of about 11,500 square miles of which 850, or slightly over seven per cent, can be classified as good winter range. The remainder of the Valley contains lakes, swamps, tall spruce-birch forests, or inaccessible areas that produce practically no winter forage.

Prior to the mid-1930's, the Susitna Valley had a very small moose population. After that time, extensive winter ranges, created by fires started during construction and maintenance of the Alaska Railroad and settlement of the Matanuska Valley, became available. Some were caused by land clearing and abandonment. A few wintering areas grew out of reach before moose populations were high enough to utilize them, but others were available. At the present time, a high moose population is present in the valley.

The Susitna sustains an annual hunting harvest of 500 to 600 moose. Calf production is high, and the Susitna herd appears to be growing but is close to the maximum number that can be supported by the available winter range. In some cases, the forest succession advanced faster than the moose population, and certain areas no longer produce available forage.

Other areas. — Other regions in south-central Alaska producing moose are the Copper River, Alaska Peninsula, and Yakutat. The Copper River drainage has been burned a number of times, and various areas are beginning to produce extensive winter food. At present, the moose population is much smaller than the ranges will support, but the herd is rapidly growing. Moose on the Alaska Peninsula have increased greatly in recent years. The moose ranges on the Peninsula are beyond the spruce zone, and it is believed that browse plants are much slower growing than in other regions. While little is known about Peninsula moose ranges, it is probable that browse production in this area is the result of recovery from volcanic activity that occurred along the Peninsula from 1910 to 1930.

The small moose herd presently near Yakutat is the result of migration into the region after glacier recession allowed a number of forage species to get a start.

All of the important moose ranges in southern Alaska are the result of some disrupting influence that removed the original forest cover and allowed young second-growth browse species to become abundant and available to moose. The most important of these influences has been fire.

Other influences of less importance have been beaver activity, where abandoned ponds have filled and become willow patches, flooding and ice activity, recession of glaciers, and regrowth on abandoned cleared land. Summer range is abundant throughout southern Alaska.

In summary, it may be noted that although natural browse stands support a small moose population, the present large herds near the centers of human population may be attributed to ranges created by accidental fires in the presence of nucleus herds which effectively utilized these ranges. The fact that uncontrolled fires can no longer be tolerated leaves the future of large-scale moose hunting in this area in an uncertain condition.

FORAGE AND RANGE REQUIREMENTS

Characteristics of moose.—Apparently due to inherent adaptations, the moose is somewhat more resistant to winter kill than some of the other ungulates. The moose also exhibits a greater tendency, or ability, to seek out new forage areas when food in one spot is exhausted, and by breaking down bushes, pawing through snow cover, and barking trees it is able to utilize forage which would remain unavailable to other animals.

Seemingly an unusual series of events is required to precipitate a large winter loss. On the Kenai, where moose have been abundant for 40 years, a severe winter kill is reported in the winter of 1922-23, when a very high moose population competed with a high in snowshoe hares under badly crusted snow conditions. Minor die-offs occurred in 1913, 1916, 1936, and 1946. In the Susitna Valley where high moose populations have appeared only in the last 15 years, large winter kills have not been noted.

Calf production on the Kenai range is about one-half that of the Susitna (see Table 4), an indication of the deterioration of wintering ranges.

Winter food.—Winter food habits vary according to the species available in the winter area. In 1952, available forage and its utilization were checked by the Aldous (1944) method on 1,124 one-one-hundredth-acre plots distributed in four principal Kenai wintering areas. Table 1 shows the forage available on the area and the per cent of the principal species in the diet. A number of species, such as cottonwoods (*Populus tacamahacca* and *P. tricocarpa*), high-bush cranberry (*Viburnum edule*), red elder (*Sambucus racemosa*), rose (*Rosa* sp.), and raspberry (*Rubus strigosus*) make up a small fraction of the available forage and food taken. They are, therefore, not included in the tabulations. Although willow and birch head the preference list, aspen, a considerably less palatable plant, is of importance because of the quantity of forage it produces. The 1947 burn, where 96 per cent of the available browse is aspen sucker growth, supports several hundred moose during the winter.

TABLE 1. MOOSE FORAGE AVAILABLE AND PER CENT IN DIET

Area	Available	In Diet
Kasilof		
Willow (*Salix* sp.)	62	66
Kenai birch (*Betula kenaica*)	11	15
Dwarf birch (*Betula nana*)	13	9
Aspen (*Populus tremuloides*)	12	10
Kenai		
Willow	74	71
Kenai birch	22	26
Aspen	4	2
1947 Burn		
Aspen	96	98
Chickaloon Bay		
Kenai birch	86	91
Alder (*Alnus* sp.)	11	7

The analysis of 96 stomachs from animals killed in the winter moose season or during the winter by Alaskan Railroad trains contained the following: Willow 53 per cent, birch 32 per cent, cottonwood eight per cent, aspen four per cent with seven other species making up three per cent.

Winter range requirements.—A close check of moose wintering on 25 square miles of the better willow and birch range in the Kasilof area revealed that 440 moose achieved proper use (approximately 50 per cent of the current year's growth utilized) after occupying the range for one and one-half months. With the required use of winter range extending over a five-month period (early December to early May), this particular area would support 132 moose for the winter period under proper use. Hence, five to six moose to the square mile on the good winter ranges in this area constitutes maximum stocking. There are indications that the capacity may be increased in ideal dense stands of young browse.

Ideal stocking seldom occurs in the natural state. It is typical that moose populations exceeding the capacity move into an area; consume forage, frequently to the point of overuse; and then move to other areas. Some examples of actual winter stocking are as follows: Two hundred and twenty-seven square miles of the 1947 burn had a density of 4.3 moose to the square mile in February, 1953. One hundred and fifty square miles of similar range, also in the burn but on the side away from fall concentration areas, had a density of 0.8 moose to the square mile. Ninety square miles at Kenai and Kasilof, in the best of the older ranges, had a density slightly over seven moose to the square mile.

Three hundred and thirty-one square miles near the Alaska Railroad in the Susitna Valley had a population of 5.1 moose to the square mile, and the winter ranges in the partially settled Matanuska Valley had 11.4. Large areas of climax spruce and birch have a density not exceeding 0.2 moose to the square mile. Populations on individual areas varied from 57.5 moose to the square mile on nine square miles of excellent winter range to 0.14 on 223 square miles of transects in forested lowlands where winter food is practically non-existent.

Quality of forage.—A number of twigs from willow, birch, and cottonwood were collected from moose winter ranges and adjacent areas and analyzed by the Alaska Agricultural Experiment Station at Palmer for crude protein content. These samples were taken from plants that had been heavily browsed by moose for a number of years, those that had been moderately used, and plants that had never been touched. All samples were taken from unshaded locations where there was no lack of available sunlight. All the samples were collected during March and April, 1951. The browse samples were oven-dried and the percentage of crude protein determined. Table 2 presents these results.

Utilization surveys.—Utilization surveys made by the Aldous meth-

TABLE 2. CRUDE PROTEIN CONTENT OF MOOSE BROWSE OF DIFFERENT DEGREES OF USE

	Willow		Birch		Cottonwood	
	No. of samples	Per cent protein	No. of samples	Per cent protein	No. of samples	Per cent protein
No use	7	6.13	6	8.79	4	7.28
Moderate use	6	6.03	4	7.94	..	......
Heavy use	4	5.80	5	7.43	1	5.47
Bark (comparative sample)	3	5.52	..	......	..	......

od with individual plant utilizations recorded by the visual estimate method (Hormay, 1943) have been conducted on the Kenai winter ranges over a three-year period. Table 3 shows the results of these surveys.

TABLE 3. AVERAGE PER CENT UTILIZATION OF THE CURRENT YEAR'S GROWTH ON KENAI PENINSULA WINTER RANGES

Area	Willow	Kenai Birch	Aspen
Kasilof			
1950	49	55	50
1951	48	53	46
1952	52	66	39
Kenai			
1950	41	50	13
1951	43	49	73[1]
1952	44	56	30
Chickaloon			
1952	....	22	....
1947 Burn			
1952	....	....	45

[1]Small sample.

Effects of utilization.—While an ideal situation on any big-game range resulting from secondary stages in forest succession would be one where the extent of utilization could be exactly controlled at a level where over-use would not affect the vitality of the food plants and under-use would not allow the forage species to become rank and grow out of reach, such a condition is seldom encountered in nature. Unlike pastured animals, big game on normal ranges cannot be moved to new feed grounds. Consequently, the problem becomes one of controlling numbers as close to optimum as possible, tending toward either over-use or under-use of available range as the situation warrants.

A degree of over-use is apparent on a number of southern Alaska moose winter ranges. Certain wintering areas on the Kenai and Susitna have been over-used for a varying number of years and the effects noted.

After overbrowsing has occurred for a number of years, the size and length of the twigs on forage species decrease considerably. The browse plants assume a typical hedgy appearance. Willow and birch are hardy, browse-resistant species and withstand a great deal of use, but current growth is reduced. The quality of the forage also declines as crude protein decreases on those ranges which have been heavily browsed for a number of years. Dead branches are very common, and lowered production is evident. Average leader growth decreases by one-half. Plants 15 to 20 years old are only a few feet high. Some of the browse plants have their tops broken because the moose have sought additional forage. Willows become barked and, in some cases, girdled. Aspen, which has a very low browse resistance, is soon weakened and no longer produces any forage. As over-use continues, willow, probably the most important key species, is consumed less because of lowered production; and birch is cropped more closely. Kasilof, on the Kenai Peninsula, has supported a large wintering moose population for many years. Here, the average utilization of willow and birch for the past three winters has been 50 and 58 per cent, respectively. In the Susitna Valley where over-use has not been so prolonged, the utilization has been 65 and 45 per cent. It has been noted that in an old willow stand, utilization will stop when an estimated 50 per cent of the year's growth has been consumed. This appears to be due partly to the growth habit of the bush and partly to the unpalatable nature of the remaining growth. However, younger growths are much more heavily utilized.

Over-use for a number of years, then, results in a lowering of both the quantity and quality of available forage with a resultant reduction in carrying capacity.

On the other hand, a degree of utilization which allows continued growth of the browse species also affects winter ranges. The plants comprising over 90 per cent of the winter forage in this region (willows attaining tree size, Kenai birch, and aspen) when under-used, will all grow out of reach with a few years. This condition is particularly true in the case of birch and aspen. A twenty-year-old stand of birch in the Matanuska Valley averaged about 30 feet high with practically no lower limbs or twigs available to moose. The birch had formed a dense, closed-canopy forest. Practically all willow was dead or had grown out of reach of moose. The dead or dying understory plants showed evidences of extreme over-use where the moose had been forced to subsist on a very few forage plants.

As plant succession proceeds toward a spruce-birch forest, the understory plants are crowded out until practically no winter forage is produced. This fact is borne out by the distribution of winter moose populations. Winter studies in these mature forested areas show moose densities of 0.14 to 0.77 moose per square mile as compared with 4.0 to 57.5 moose per square mile on the best ranges.

It is also probable that the quality of forage in these grown-up areas is reduced. Both Einarsen (1946) in western Oregon and Cowan (1950) in British Columbia have noted that younger stages of forest succession produced the most nutritious vegetation. Thus, under-use of winter moose range can also lead to a lesser amount of lower quality forage.

Viewing a browse stand in its entirety, under-use seems the more serious condition. With a severity of browsing where most of the bushes are kept at an available height, some browse plants will be subjected to over-use. When a rapidly growing stand of birch or aspen has out-reached the moose, the tall trees no longer produce forage and a heavy forest canopy is spread to prevent understory browse production. Of the two evils, it seems preferable to us to have a broken-down, heavily browsed bush producing some forage than one grown to a height where no forage is produced.

Relationship of burn succession to forage production and moose populations. — Observations of burns in the south-central Alaskan areas indicate that succession may follow a variety of patterns resulting in the creation of useful moose winter range for periods from zero to fifty years. Under average conditions the stand appears to furnish good forage for 15 to 20 years. The 1947 Kenai burn, totaling 290,000 acres, will have an important bearing on the future of the Kenai moose. It also offers an opportunity to observe burn ecology as it may influence moose herds. The original stand, largely of black spruce with scattered aspen trees, furnished an extremely limited range for moose. The annual January inventories in this area illustrate the build-up of wintering moose following the burn: 1950—273; 1951—344; 1952—618; 1953—1,111. This increase has occurred largely as a result of diversion of moose from other wintering areas. In 1952, during the utilization study, 487 one-one-hundredth-acre plots were checked in the burn. Sixty-five per cent of the plots contained available forage. Ninety-six and one-half per cent of the forage available was aspen sucker growth. A thorough interspersion of aspen through the original stand resulted in heavy root suckering immediately following the fire so that significant aspen browse was produced within two to three years. Five years following the burn some unbrowsed aspen has attained a maximum height of nine feet and is well on its way to becoming unavailable. However, most of the aspen has been retarded by browsing. Seedling growth of black spruce, birch, willow, and aspen is now showing up in increasing density although none of it attains a height above snow level. The present situation indicates that aspen sprout growth will furnish a substantial amount of browse for a few years until it is either damaged from overbrowsing or grows out of reach. By that time, birch and willow seedling growth should be producing a larger volume of forage. The early and widespread revegetation by black spruce indicates that the forage producing years of this burn may be of relatively short duration.

Settlement.—The activities connected with a moderate degree of settlement, such as timber cutting, land clearing, and escape of brush fires, create forage conditions favorable to moose. The moose apparently has few inhibitions regarding the use of settled areas, and wintering populations may build up quite high as noted around Palmer, Wasilla, Kenai, and Kasilof. Increased settlement, however, through farming and physical development of the land results in a gradual elimination of areas from forage production. Records of some areas in the United States indicate that widespread settlement over a long period of time results in a gradual elimination of the moose.

POPULATION DYNAMICS

Composition counts. — Composition, distribution and population trend studies are here made most effectively with aircraft. Experimentation over a period of years resulted in the selection of November as the best time for composition counts, after the rutting season and before the bulls have shed antlers. At this time the leaves have fallen from the deciduous trees and snow cover makes the animals more easily seen. A large number of moose representing all portions of the moose range are individually examined at a low altitude. Usually a total of about 3,000 moose is so checked on the various ranges and recorded in categories as cows, calves, adult bulls and young with small antlers. By the first week in December sufficient bulls have shed their antlers that counts are no longer accurate. Table 4 summarizes these data for a three-year period on the principal ranges. Records of old Kenai composition surveys show that no modifications of sex ratio occurred before bull seasons were introduced in 1933. Nineteen years of bull seasons have resulted in a ratio of approximately one bull to two cows. A compilation of all ground observations made during the summer period shows a cow-calf ratio of 100:31.9, whereas the late winter ratio is 100:23.7. This indicates an approximate 25 per cent loss during the first year. These summer counts probably do not reflect accurately the loss during the first few weeks of the calves' lives. The proportion of single calves to twins, which has varied from 1:2 to 1:15, does not seem to follow any definite pattern and is as yet not clearly understood. Post-mortem examination of cows during the pregnancy period is carried on, but no significant figures are as yet available.

Lower jaws are collected wherever possible for future age studies. In a collection of 21 long-yearling class jaws and antlers, only two had spike antlers, most having a fork or even a small palm.

Population inventories.—Inventories for the determination of population trends are made in January and February when moose are on the wintering areas. These are frequently total counts on sample areas where it is desired to secure information on probable total numbers or to learn of shifts in populations from year to year. In some areas, one-

TABLE 4. MOOSE COMPOSITION SURVEYS IN SOUTHERN ALASKA

	Young Males[1]	Adult Males	Total Males	Female[2]	Females with Calf	Females with 2 Calf	Total[1] Females	Total Calves	Total Moose Checked	Bull-Cow Ratio	Calf-Cow Ratio	Per Cent Calves
Kenai												
January, 1950	......	......	......	......	......	....	......	76	1,158	....	....	6.6
November, 1951	100	441	541	630	132	26	788	184	1,513	69:100	23:100	12.1
November, 1952	110	225	335	533	122	8	663	138	1,136	50:100	21:100	12.1
Susitna												
January, 1950	......	......	......	......	......	....	......	188	1,140	....	....	16.5
November, 1951	145	369	514	403	385	60	848	505	1,867	61:100	60:100	27.1
November, 1952	86	232	318	457	278	30	765	338	1,421	42:100	44:100	23.8
Copper												
November, 1952	46	161	207	224	96	20	340	136	683	61:100	40:100	19.9
Alaska Peninsula												
January, 1953	......	......	......	......	40	20[3]	......	83	518	....	....	16.0

[1]Animals with small antlers distinguishable from the air.
[2]Females recorded include yearling females.
[3]On very rare occasions a calf will be noted without a cow in attendance.

half-mile strip counts are made in the manner of waterfowl surveys. Inventories on the Kenai sample areas have shown a 35 per cent increase over a three-year period. This is believed to be due in part to moose coming into the 1947 burn from areas adjacent to the sample area. On the Susitna area a 30 per cent increase has been noted.

HARVEST AND MORTALITY

Kill records.—Moose kill records for the Territory are provided through a hunters' report made when the succeeding year's licenses are obtained. This Territorial kill has risen from 1,547 in 1944 to 3,900 in 1950. A hunter's report was required within five days of the kill for moose taken on the Kenai Peninsula in 1952. The take of 371 moose so reported in the 20-day September season is believed to have reduced the bull-cow ratio. The average antler spread was 41.1 inches for 274 antlers which were reported. Thirty-two per cent of the bulls were in the young age classes (below 30-inch spread).

Unfortunately, information regarding the number of animals harvested in the Susitna Valley is not precise. During the general open seasons, kill records were obtained from cold storage lockers, observations, and reports. Accurate information was obtained during permit hunts designed to reduce populations in certain areas. Following are the records of harvests during the 1951 and 1952 hunting seasons:

	1951	1952
September 1-20	400	450
December 1-10	60	75
Permit Hunt (restricted to 75 permittees)	54	50
	514	575

Mortality and predation.—Mortality records are kept on all moose found dead. During the past four years, railroad and highway kills, illegal hunting, and death from natural accidents have been the chief causes noted other than legal hunting. Dead moose are frequently examined by wild animal disease pathologists of the U. S. Public Health Service. There has been little evidence of serious disease; however, of 11 sets of lungs checked in Susitna moose by Dr. Robert Rausch, four contained cysts of hydatid tape worms (*Echinococcus granulosus*).

Predation by wolves in the Susitna, Copper River, and Alaska Peninsula is a factor in mortality, the importance of which is not completely known. On the Kenai where wolves have not been present in effective numbers during the era of moose abundance, a large black bear population has been responsible for a substantial calf mortality [Palmer (1938), Sarber (1944), and Chatelain (1950)].

The interaction of predation and range influences operating on the Kenai herds has not been defined at this time. Conditions are now present through study of population dynamics in the 1947 Kenai burn which may result in a resolving of this question after a period of several years' investigation.

MANAGEMENT DISCUSSION

South-central Alaska requires a high moose population to satisfy hunting demands. Existing large herds are due to secondary successional ranges accidental in nature. If these ranges are eliminated through forest succession and land clearing, the moose herd which can be supported on climax types, will be far below that necessary to sustain heavy hunting. Therefore, a large part of the long-term investigations are concerned with studies by which it is hoped to place the transitory phenomenon of a high moose population on a more permanent basis.

It is known that areas of moose abundance change as old ranges grow out of reach and new ones are created. For example, records during the last part of the 19th century indicate an abundance of moose in the Susitna Valley, while observers from 1910 to 1936 note a scarcity.

Very few moose were reported on the Kenai Peninsula until 1900. The caribou that inhabited the Peninsula at this time disappeared during the first decade of the 20th century.

The possibility of controlled burning is being investigated as a means of creating and preserving winter ranges. Present fire control programs are so effective in these areas that more moose range is being lost through forest succession than is being created. Timber management on the Kenai National Moose Range is directed toward production of moose forage rather than timber.

The Kenai Peninsula, where the extensive 1947 burn is relieving the near-critical winter range condtions, may be expected to support a good population for a number of years. The present moose population now at maximum range capacity, is being maintained to utilize as much as possible the developing forage in this burn. The amount of winter range resulting from developing vegetation is not only a factor in the course of succession, but is also related to the maintenance of available range by a moose population which through browsing keeps growth at a height available for use. Within a few years, an increased harvest is indicated for this herd.

The future of the Susitna moose herds is problematical. At present, some winter ranges are rapidly growing out of reach and others are being over-used. The moose are increasing. Present indications are that the moose population will cease climbing and gradually decline as some winter areas grow out of reach and others become over-used. Controlled burning can partially alleviate the winter range problem but cannot completely remedy it. Widespread uncontrolled fires are unlikely. If an economic change in the Territory occurs, and cleared homestead land is abandoned, some new moose range will be created. Otherwise, moose numbers in the Susitna Valley can only decline.

The Copper River shows great promise as a moose habitat. At present, there is a great deal of forage, and the herd is increasing. It is probable that this area is destined to produce high moose populations. Restrictions on available range probably will never allow Yakutat or the Alaskan Peninsula to assume the importance of the other areas.

SUMMARY

The greater amount of Alaska moose investigations are centered on the important Susitna and Kenai Ranges. On these ranges, large moose populations near heavily settled areas have resulted from past successional disturbances, mainly fires.

Although various winter losses have ocurred, moose are more resistant to winter kill than some other ungulates.

Willow, birch, aspen, and cottonwood, in order of preference, supply 95 per cent of the winter forage.

Between five and ten moose to the square mile may be accommodated on the best of the winter ranges under proper use. However, actual stocking is frequently at variance with these figures.

A narrow margin exists between over-use and under-use of the ranges; serious under-use resulting in a greater loss of forage-producing capacity than over-use. Due to the hardy characteristics of willow and birch and the resistance of moose to winter kill, a developing browse stand may warrant the maintenance of maximum moose populations.

A 290,000-acre burn in 1947 on the Kenai Peninsula induced an increase in moose population of about four hunderd per cent between 1950 and 1953. Significant forage was produced three years following the fire through aspen sucker growth, which furnished 96 per cent of the available forage. Seedling growth of spruce, birch, willow, and aspen is also revegetating the area.

Extensive herd composition counts are made yearly in November by aircraft with results as tabulated. Population trend counts are made in January and February on sample areas and transects.

Composition counts indicate that a 25 per cent loss in calves occurs from summer to late winter.

Kill records for the Territory are obtained from license application reports. On the Kenai Peninsula, a hunter's report five days following the kill has furnished data on various phases of hunting. Locker plant records and field checks give up to date kill records on other areas.

Highway and railroad kills, illegal hunting and accidents have been the highest known losses in the past four years. No serious disease conditions have been noted.

Predation by wolves and bears is a factor in some areas.

Long-range management is aimed at placing large moose populations on a sustained basis.

Due to developing range in the 1947 Kenai burn, a maximum population is desired for a few years to aid in creating winter range. Susitna herds have reached maximum capacity and increased harvests are indicated.

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EFFECTS OF LAND USE ON MOOSE AND CARIBOU IN ALASKA

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Moose and caribou are the most important ungulate mammals throughout most of Alaska by the criteria of bio-mass, area occupied, and use for meat. Our objective has been to view the long-term prospects of moose and caribou in terms of past, present and probable future trends of land use in the Territory.

ECOLOGIC AFFINITIES OF MOOSE AND CARIBOU

Let us consider the ecologic affinities of the two species.

The moose occupies a habitat of wet forest edge, or tundra with expanses of willows in the draws. It achieves highest density in forest areas that have been opened by fire or any other form of timber removal, permitting regeneration of willow, birch, or aspen. Moose may occupy in summer a variety of habitats, including even heavy unbroken forest or high mountain valleys, but the quality of the winter range, which in the final analysis determines population density, is a direct function of the amount of young willow, birch, or aspen protruding above the surface of the snow. These critical browse plants are especially characteristic of *secondary* stages of forest succession. To be sure, moose follow the willow draws northward across the tundra almost to the Arctic Ocean, and there willow represents riparian climax. But populations are comparatively sparse and not to be compared with densities achieved in cleared spruce lands. The moose itself may thus be considered primarily an animal of a sub-climax biota.

Conversely, the caribou seems to require a winter range well supplied with various fruticose lichens, particularly of the genera *Cladonia* and *Cetraria,* which are part of the *climax* flora of forest border (taiga) and to a lesser extent of tundra. Like the moose, caribou wander into many types of country in spring, summer, and autumn, from coastal low tundra to high glacial valleys, but all winter ranges examined by us contained in the ground cover a fair amount of climax lichen growth which supplies an appreciable, and seemingly an indispensable, part of the winter caribou diet. The caribou, then, may be looked upon as a member of a *climax* biota.

The considerable overlap in gross areas of moose and caribou range does not disguise the fact of ecologic segregation of the two species along lines of successional stages of vegetation. It follows that changes in climax ground cover may affect the moose and caribou quite differently.

THE IMPACT OF WHITE SETTLEMENT ON RANGE CONDITIONS

The arrival of the white man, with his vices and devices of land exploitation, introduced a set of ecologic influences distinct from those endemic in thehunting-food-gathering cultures of Eskimo and Indian. Fire is much the most important of these influences.

An astonishingly large proportion of the lowlands of central and southern Alaska has burned in the last century. Miners, trappers and hunters—men who deeply penetrate a country—and more recently the defense forces, have started far more fires than would naturally have occurred. In saying this we take it as axiomatic that the passage of fire through this kind of country is natural, though perhaps at very long intervals. Unfortunately, no fire statistics are available which would permit us to compare the areas of recent fires with those occurring previous to white infiltration. It is obvious to the traveler that much more than half of the taiga has been burned in the immediate past. H. J. Lutz (1950), who has exhaustively studied the history of fires in interior Alaska, estimates that 80 per cent of the white spruce has burned in the past half-century. R. R. Robinson, in charge of the Division of Forestry in Alaska (Bureau of Land Management) concurs in this estimate.

The quickened rhythm of fire has in general favored the extension of willow-birch-aspen, and concomitantly reduced the original stands of lichen which burn easily and take so long to regenerate. Such a condition has encouraged the spread and local increase of moose, at the same time eliminating or greatly reducing the winter range usable by caribou. For example, caribou have been extirpated from the Kenai Peninsula and in fact from all the lowlands adjoining Cook Inlet; moose in the same region have achieved higher density than anywhere in Alaska. Virtually all of their range has been burned and reburned. Caribou are relatively scarce in the upper Copper and Susitna basins; moose are increasing. Over half this area is burned. Caribou have been materially reduced in the great Yukon drainage; moose, though by no means numerous, are widespread and holding their own or locally increasing. Such parts of the Yukon as we visited were largely burned. Accelerated burning, in other words, has influenced moose favorably and caribou unfavorably over that large part of Alaska south of the Arctic Circle. Caribou in the north, where fire is not a factor, are quite a different problem and will be discussed separately later in this paper.

Clearing of forest *ad hoc*, such as in the building of roads and railroads and for farms, with perhaps consequent abandonment, has the same effect. Willow, aspen and birch come back strongly, and the area becomes choice moose range, whereas caribou shun such disturbed areas.

A second major range influence, which has materially circumscribed the area occupied by caribou has been the introduction of reindeer in the western coastal regions of Alaska and locally in the interior. From 1892 to 1932 the reindeer herds increased and occupied most of the coast from the Colville delta on the Arctic Ocean westwards and southwards to Lake Iliamna at the base of the Alaskan Peninsula. The total number of reindeer at the peak may have been over 600,000. Lack of adequate knowledge of range limitations and poor herding practices (repeated heavy grazing of local areas of range), led to exhaustion of the lichens and wholesale losses among the reindeer herds. Burdick's (1940) count in 1937 when the Government took over the reindeer from private interests, was 252,000 animals. Numbers had sunk to 155,000 in 1941. There remain only 26,735 reindeer in 1952 according to figures supplied to us by the Alaska Native Service.

The die-off is blamed in part on wolf predation and absorption of reindeer by caribou herds, and in part on careless husbandry by the Eskimo owners (Lantis, 1950, and others). The range situation is recognized but usually minimized. Yet the collapse of reindeer populations followed the same pattern on islands, where there are neither wolves nor caribou nor herding problems, as it did on the mainland. On Nunivak Island for example a herd of 22,000 dropped to below 5,000 in the late 1940's, and examination of the range today shows the scars of overgrazing and browsing by far too many animals. The lichens are virtually gone. The same phenomenon has been well described for St. Paul Island by Scheffer (1951). In short, where reindeer have grazed heavily, the range has been damaged and in many localities made untenable for both reindeer and caribou. On these grounds alone one can account for the disappearance of caribou in most of western Alaska and in such isolated portions of former reindeer range as the base of the Alaska Peninsula.

The dissection and breaking apart of climax caribou range into small isolated pieces may have had deleterious effects on the population, over and beyond the actual loss of gross area of range. We have come to wonder whether the thrift and productivity of small bands, confined to isolated ranges, may be appreciably less than in nomadic herds wandering free over large ranges. A report by Scott *et al.* (1950) shows clearly how many separate little caribou bands now exist in central Alaska in what was once contiguous range for tremendous numbers of animals. The ecologic and sociologic implications of this change are worthy of careful observation.

There is one other factor which may be furthering the spread of moose northward and tending to restrict the caribou on the southern ranges, one not caused by man; namely, the general, slight, Holarctic warming which recorded meteorological observations over the last century show to be taking place. We know, also, that the retreat of the glaciers has in some places removed an actual physical barrier to moose, as along the Taku River. We call to mind the work of Kalela (1948, 1949) in Finland who shows that in the Old World some animals and plants of the temperate region are moving northward in their distribution; conversely, some northern species are failing to reach as far south as they formerly did. As far as moose and caribou are concerned, this slow, possibly temporary, climatic change has worked in the same general direction as have the disturbances caused by man and has probably increased the pace of population change. The remarkable increase of moose north of the Brooks Range may be due entirely to this climatic factor, favoring the spread of willow. Dr. J. L. Giddings of Pennsylvania tells us that tree ring data from the northern Arctic show clearly a progressive widening of the rings since 1900.

To summarize the discussion of range influences, we repeat that changes in vegetation resulting from white occupation of Alaska have on the whole acted for moose and against caribou. The population trends of the two species correlate closely with the changes in range. Climatic trends may have accentuated these effects.

HUNTING AND PREDATION

Hunting at a greatly accelerated rate has been another impact of white penetration in Alaska. Uncontrolled killing of big game was probably worst in the period of the widely dispersed trapper-prospector population. This was also the period when native Indians and Eskimos obtained general access to modern firearms and ammunition. For many years both moose and caribou were indiscriminately overshot, without effective government restraint. More recently, trapping and prospecting have both declined in the style they were formerly followed, and the attitude of most Alaskans has changed to one of desiring to conserve big-game herds instead of merely to exploit them. Furthermore, the extension of the work of the Fish and Wildlife Service has had an immense effect on ordering and codifying the situation. In much of southern and central Alaska it is our impression that the hunting kill has been reduced to less than annual increment, hence that hunting has ceased to be the prime limiting factor on big-game numbers that it recently was. The general increase of moose is *prima facie* evidence of the growing success of the game protective program. That caribou are not responding equally seems attributable largely to range limitations defined above.

By the same token, one has difficulty explaining current population changes on the basis of wolf predation. There can be little doubt, it seems, that wolves have increased in recent years over much of Alaska. The vigorous control program of the Fish and Wildlife Service is beginning to reverse the trend in some localities. Through this era of rise and then local decline of wolf numbers, the trends in moose and caribou populations have been generally constant—the former increasing, the latter decreasing south of the Arctic Circle. The considerable increase of moose in the Colville River valley, for example, occurred in the face of rising wolf numbers. So also did the more gradual spread of moose in the Yukon Valley and on the Alaskan Peninsula commence before wolf control began.

Intensive wolf control has been applied for several years in the Nelchina Basin, and there the caribou herd has responded with a substantial increase—from 4,000 to 7,000 in the past five years. Where control has been merely extensive, no response has yet been noted. A question arises as to how far the control of wolves should be pursued in the attempt to increase caribou.

We wish to make it clear that we are not filing a blanket objection to predator control as a legitimate tool of game management. There are indeed situations where wolf removal may be highly beneficial in restoring depleted breeding herds of moose or caribou *on ranges which can carry more animals*. But in each case where an increase in breeding stock is deemed an immediate objective of management, it should be established in advance that the range will support more animals. On the Nelchina area, such has not been proven to our satisfaction, for the limited area of winter range appeared to be very heavily used already. It has been the history of big-game management throughout North America that range limitations are usually recognized and defined *after* excess breeding stocks are created by overzealous protective measures. We cannot afford to repeat that error on Alaskan caribou ranges which are so highly sensitive to overgrazing, as shown by the reindeer experiment. In other words, in making the transition from a condition of overshooting and heavy predation to one of closely regulated shooting and much reduced predation, we need take care not to go too fast or too far. Excessive control of decimating factors can lead to serious overpopulation of big game with consequent wasteful winter losses to starvation or parasitism, lowered fertility rates among the breeding females, and range depletion. Some of these symptoms are evident even now in the extremely dense moose populations on parts of the Kenai Peninsula. We are concerned lest they crop out in the remaining herds of southern caribou, which, by virtue of their accessibility to population centers, are very important recreational assets.

Coming now to the caribou herds north of the Arctic Circle in Alaska, we interpret the evidence as indicating that caribou have increased rather than decreased in the past half century. Many herds, numbering in the thousands, have been seen in the past five years on ground where explorers like Stefansson, Leffingwell, Smith, Mertie, Schrader and Peters, who covered most of the Brooks Range and Arctic plain in the early 1900's, spoke of scattered hundreds. At that time a well-dispersed Eskimo population hunted asiduously. Decrease and concentration of the Alaskan Arctic Eskimo population, and lessened dependence on caribou, have greatly reduced hunting pressure. Our observations on the influence of caribou on Arctic ranges lead us to say without hesitation that the tundra is in reality a highly sensitive lichen range, very much inferior to taiga range (noted also by Banfield, 1951), with relatively low productivity and slow capacity for recovery. There are more caribou in the north now than for many years past, and it is by no means established that the country can carry in perpetuity even the present population, let alone an increased number. Therefore, efforts to increase the northern herds by control of wolves may again be a dangerous policy unless compensatory human hunting pressure is adequate. If this brittle climax range is damaged by overgrazing, the caribou population might well crash and the resource be lost. At the moment, no such overpopulations are recognized in the caribou herds of Alaska, but who among us would recognize them? Until we know more precisely how to measure carrying capacity of tundra caribou range, we had better elect deliberately to understock rather than risk overstocking.

MANAGEMENT PROSPECTS

The processes of occupation and development of Alaska can be guided and locally even curbed but they cannot be reversed. A continuing change in climax vegetation is to be expected, and the results, as they affect moose and caribou, presumably will follow trends of the past.

There is good reason to think that moose will continue to increase and spread as new winter ranges are created by removal of the spruce forest. As far as we can see at the moment, there is perhaps no better use for much of the poorer forest land than to be moose range, so managed as to sustain a maximum number without endangering the range. There is also reason to think that the controlled use of fire to improve critical areas of winter range in central and southern Alaska would be advantageous and, at least in some localities, quite practicable. But such deliberate burning would demand exact knowledge of when, where, and how to burn to achieve the desired reproduction of moose browse without destroying the soil complex. Moose range can be destroyed by a burn as readily as it can be created and preparedness for fire control is expensive. Such intensive management is most practicable and desirable in accessible hunting grounds, near population centers, where demand for hunting and for meat is greatest.

There is little object in creating large moose populations unless the harvest is to be taken. In general, present moose hunting regulations in southern Alaska, where the animals are most numerous, seem to us overconservative, particularly when coupled with rigorous predator control. It is our feeling that much larger harvests could be removed from the Kenai and Susitna, for example. At the same time, efforts to rebuild breeding stocks may be necessary for some time to come in parts of the Yukon basin and other lightly stocked ranges.

The prospects for caribou are not nearly so good. Caribou, depending upon a climax vegetation, will probably continue to diminish in numbers as their range shrinks with further human encroachment and disturbance. Some great areas of tundra on the slopes of the Brooks Range and Arctic plain probably can be preserved more or less intact far into the future if proper steps are taken to insure protection from overgrazing, and on the south side of the Brooks Range, from fire; fortunately, the Arctic tundra does not burn. But it is unlikely that the great caribou herds of central and southern Alaska can be restored. Rather, efforts at restoration should be gauged by the realization that money and effort so invested can bring but limited returns on ranges no longer suitable for large herds, and even the most conscientious endeavor, along lines of protective legislation and predator control, cannot alter this ecologic fact. Much light could be shed on solution of this problem if in the near future, a full socio-ecological study of the caribou could be made in an undisturbed environment, such as the eastern Brooks Range. Meantime, it is of extreme importance that the remaining lichen ranges be protected from fire. A plan of land-use zoning might well be adopted jointly by the several agencies concerned with forest and game management which would provide for experimental burning of designated moose ranges, at the same time furnishing active protection from burning of the remaining caribou ranges and of the better silvicultural sites. The controlled use or exclusion of fire should be part of an integrated plan of game management.

It is almost inevitable that after occupation of a country by technological, pastoral or agricultural man, we find ourselves struggling to *preserve* the animals of ecological climax status, such as bison, musk-ox and caribou. The opportunity to *manage* and produce game lies largely in populations of those animals which reach maximum abundance at stages of sub-climax or secondary succession, such as deer, elk and moose.

ACKNOWLEDGMENTS

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DISCUSSION

DR. DEVOS: Thank you, Dr. Leopold.

May I now ask for comments from the floor on the two papers presented by Edward Chatelain and Dr. Leopold, which emphasized calling for the influence of ecological changes on big-game populations, and getting the best help for individual species?

MR. PRESNALL: Before asking this question, I would like to compliment Dr. Leopold on a very excellent presentation of a paper on one of the most difficult game-management problems we have in North America.

The question I have is this, relative to the Alaskan Peninsula area: Did you have opportunity, or did Dr. Darling have opportunity, to look at the ranges and the situation there as compared to others? The reason I ask that is that it was my impression, based upon very limited observation, that this might be one place in Alaska, perhaps the major place, where we could look to justifiable increase of caribou on the basis of underutilization of lichens at present.

DR. LEOPOLD: Yes, we did see the lichen range there, Cliff. J. Hammond and Dave Spencer took us to Becharof Lake at what was approximately the center of the winter range of that particular herd of caribou which migrated up and down the Alaskan Peninsula.

The lichen range there was, in our opinion, considerably inferior to some of the lichen ranges to the north and east. Although that was one of the first winter ranges we saw—it was the first—and we were not properly prepared to make comparisons, I do not think it has a very high carrying capacity.

There is another factor, however, which seems to affect the herd; namely, domestic reindeer occupied the base of the Alaskan Peninsula for a period in the twenties and thirties, I believe, and completely cut off the caribou of the Alaskan Peninsula from the mainland; I mean they ate the range up, and the animals ceased to make that transition. Hence, the present herd is limited to the Alaskan Peninsula proper, and has not yet crossed back over range which was occupied, ten or 15 years by reindeer.

Perhaps, as the range recovers—and, certainly, that old reindeer range is recovered—the Alaskan Peninsula herd may begin to increase again, I hope.

MR. FRANK MULKERN: I unfortunately came in a little late; this might have been mentioned.

Is there any estimate of the total number of surviving caribou and musk oxen, both in Canada and in Alaska; any estimate in number of animals?

MR. CHATELAIN: Our general estimate of caribou, which was made approximately four years ago, was about 160,000 animals for the entire territory. This includes both the Arctic herds, the interior herds, small remnant bands, and the Alaskan Peninsula.

DR. PETERSON (Ontario, Canada): I have been quite interested in the relationship between moose and caribou for some time now, and I thought perhaps some observations we made in the eastern part of the range might fit in here and help to fill out the picture a bit.

As you may or may not know, the region north of Lake Superior at one time was entirely a caribou range; the moose did not occupy that territory. The same is true of Central British Columbia, and it is rather interesting, at the same time, roughly about 1850, that the caribou began really to decline, and the moose began to move into these regions. In Ontario particularly, we have been able to trace the movement of moose into this region north of Lake Superior.

The question of what has happened seems to have been the same as in Alaska; and, as far as we have been able to tell, in that part of the country the same holds true. Opening up the country, the fire and destruction of the caribou habitat developed ideal moose habitat, so that, in these particular regions, the caribou is relatively scarce now, restricted to a few pockets. In Ontario particularly, islands are the most notable places we can find the caribou.

We still have another complicating factor there, though, since we have a third wave of succession in big-game setup. The moose seems to have replaced the woodland caribou in a great part of its range; but, in addition, we have a third animal moving up to replace the moose; namely, the white-tailed deer. We find a very interesting ecological development here with this wave of caribou, woodland caribou particularly, the moose, then the white-tailed deer. It is rather interesting to note that, in the regions where moose were formerly abundant, the white-tailed deer is now taking over; it seems to be in such regions as Nova Scotia, New Brunswick, Southern Ontario, and Minnesota.

It would be a very interesting thing to see, with time and this gradual northward shift of these things, what happens to our big-game populations.

I, for one, feel that this is a stage in evolution which we must consider in any plan, because I think the plan has not been set.

DR. DEVOS: There is some time for one more question.

DR. CAHALANE (National Park Service): I agree with Mr. Peterson that, apparently, the fauna and flora in Alaska are changing sufficiently so that there is a major shift now in the general evolution of the animal life, especially the larger mammals.

I would like to ask Dr. Leopold what he and Dr. Darling felt about the range of the caribou on the northern side of the Alaskan range and the general range of McKinley Park. The caribou of that region are alleged to have decreased very markedly in the last 40 or 50 years, and I am especially interested in any determinations they might have made concerning the condition of the range and future capacity of it.

DR. LEOPOLD: I am going to refer that question to Ed Chatelain. He knows that area much better than I do, Vic.

We started the caribou on their summer range; but the winter range runs north of Mount McKinley, and that we did not visit, so I have no opinion.

MR. CHATELAIN: The McKinley Park herd, spending summers in McKinley Park and wintering at the Lake Minchumina region, at the time we surveyed it, contained about 5,000 animals. However, we have reason to believe that part of the decrease in that number is a result of a splitting off of a portion of that herd which proceeded along the west slopes of Alaskan range, and has recently taken up residence in the vicinity of Farewell on the north side of the Alaskan range.

DR. TRIPPENSEE (Massachusetts): Dr. Leopold, can you describe the partial use of the lichen plants or lichen range by the caribou? Is it a complete use of parts of the plants, or is it a partial use of all the plants?

DR. LEOPOLD: The ones we saw, the caribou had come down obviously through the snow; they apparently located these lichens by scent, dug a hole down through the snow, and proceeded to dig a core three or four feet in diameter and six inches in depth. After the snow melted, the shreds of lichen which did not actually fall to the ground were capable then of sprouting.

So a clump can recover completely and ten years later be ready to supply one more meal. The rate of growth is extremely slow, however. These things grow about a sixteenth of an inch a year; a good clump is 16 inches deep. So, every few years, caribou may gradually deplete the lichen.

There are certainly plenty of shreds left on the ground which can reseed the lichen, but the growth rate is so slow.

DR. DEVOS: In closing this discussion, I might refer to the controlled use of fire.

In Ontario, we have put out several feelers about this question, but we have run into considerable trouble with our friends, the foresters. They have been very careful in their fire-protection system, and they feel this controlled use of fire might cause them considerable public-relations problems. I do not know whether it is true in Alaska, but at least I feel that, in Eastern Canada in general, we will have to start with a very detailed public-relations program before we can get to this management-control method.

CHAIRMAN HICKIE: Now, we are still going to pursue the moose from Alaska across to the other side of the North American continent. Mr. Pimlott!

NEWFOUNDLAND MOOSE

DOUGLAS H. PIMLOTT
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Newfoundland's big-game research program was initiated in 1950 by what is now its Department of Mines and Resources. Preliminary reconnaissance was carried out during the summer of that year with this study getting under way on a full-time basis in 1951. We are concentrating research on moose, for this species provides over 80 per cent of the annual big-game harvest. This report deals with the history of the moose population, features of the range and preliminary findings essential to understanding big-game problems in the island of Newfoundland.

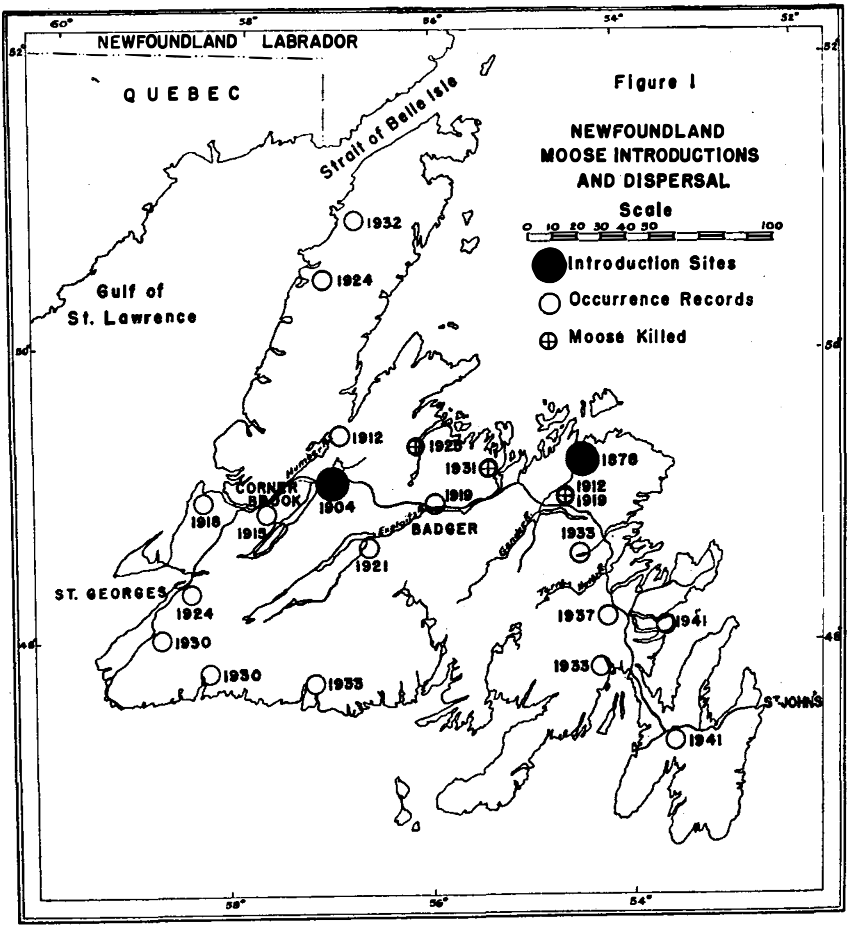
NATIVE AND INTRODUCED MAMMALS

The indigenous fauna of Newfoundland consists of only 14 species (Anderson, 1946). The caribou (*Rangifer caribou*) is the only member of the Cervidae, and the arctic hare (*Lepus arcticus*) is the only member of the Leporidae. Moose (*Alces americana*) and the varying hare (*Lepus americanus*), by far the most economically important species, were both introduced. The wolf (*Canis lupus*) was formerly present but is now extinct. Black bear (*Euarctos americanus*) and lynx (*Lynx subsolanus*) are the only possible big-game predators.

HISTORY OF MOOSE IN NEWFOUNDLAND

Introductions.—According to the files of the Department of Mines and Resources, moose were introduced to Newfoundland on two different occasions. The first introduction was made in 1878, when a bull and a cow were brought from Nova Scotia and released at Gander Bay, in the northeastern part of the island (Figure 1). In 1904, seven animals, four cows and three bulls, were captured in the Miramichi area of New Brunswick. These animals were held in a small enclosure at North Sydney, Nova Scotia, during a shipping tie-up, and three of them died. In June 1904 the remaining four, two cows and two bulls, were released near Howley, in the Grand Lake area (Figure 1).

The question of the success or failure of the first introduction has never been answered. In 1912 an adult bull was shot on the Gander River, and Howley (1913) considered this animal one of the descendants of the first pair introduced at Gander Bay. Subsequent sight records of a single immature animal in 1916, a bull and a number of cows in 1917, tracks of at least four in 1919, and a dead bull found in a river in the same year, gives support to Howley's theory, for in 1919



the first pair of moose was reported at Badger, equidistant between Howley and the Gander River. A simple calculation of progeny from the four animals introduced at Howley, allowing 100 per cent breeding success, no mortality, and 50 per cent twin births, indicates that there probably were not more than 11 adult bulls on the island in 1912. That one of the 11 should have arrived at the Gander River from Howley, over a hundred miles away, and at a time when none had been reported between Howley and the Gander, seems somewhat improbable.

Certainly, if the first introduction was a success, the spread of these moose lacked the dynamic results of the second introduction. Large-scale forest fires which swept the eastern section of the island in the two or three decades following the first introduction could have been a factor. The classification by Phillips (1928) and Leopold (1933) of the types of response of game birds to transplantation seems to fit the introduction of moose to Newfoundland. The early attempt may have been a case of straggling failure of recessive establishment; the second attempt certainly was complete establishment providing most of the stock which eventually populated the entire island.

Rate of spread.—Information obtained from departmental files and from personal interviews indicates the rate of spread. Within 10 years of the second introduction, moose were being reported up to 40 miles from Howley, and in 15 years they were reported 50 miles away at both Badger and Serpentine Lake, with a breeding population at least in the Serpentine area. In 20 years the radius had extended to at least 80 miles with reports from St. George's and River of Ponds. Within 30 years they had been reported from Gambo Lake, Placentia Bay, Grand Bruit and Hawke's Bay, at straight line distances of up to 200 miles from Howley. In 1941 moose were reported from the Avalon Peninsula and in 1945, forty-one years after the second introduction, moose were so generally distributed that an unrestricted open season was declared in all areas but the Avalon and Burin Peninsulas.

The history of the population appears to consist of two main periods. The first period of approximately 25 years was one of rapid dispersal and low densities. The second period, which extends to the present time, was one of build-up to high densities.

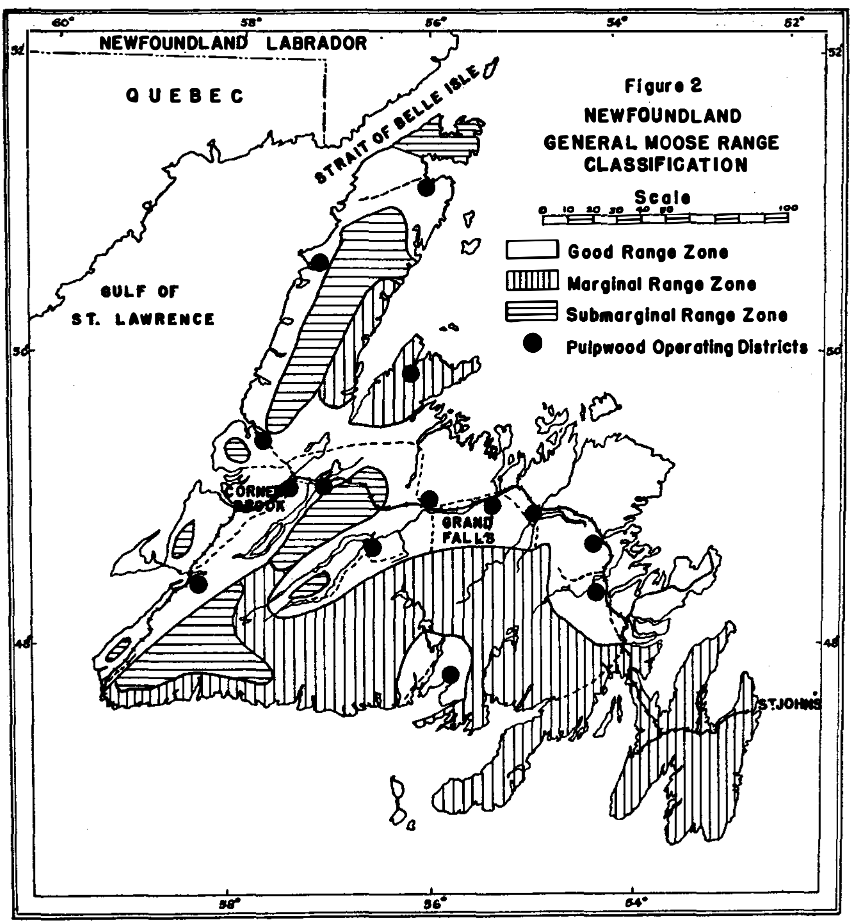
In the winters of 1932, 1933 and 1934 two forest survey parties working in a vast area between Red Indian Lake, Terra Nova River and Fortune Bay, did not observe any moose sign although records indicate that animals were in the area. Within 10 years moose were becoming quite common in the same area and throughout most of the island.

RANGE CLASSIFICATION

Newfoundland is part of the boreal forest region and over much of the island the forest associations are dominated by some combination of balsam fir, black spruce, white spruce and white birch, with balsam fir the most common dominant.

The area of the island is approximately 43,000 square miles. Of this total 36 per cent is classed as productive forest, 6 per cent as nonproductive forest, 44 per cent is subalpine tundra, fire barren or scrub-covered land, 14 per cent is water (Anonymous c. 1946). The productive forests are located mainly in the watersheds of five principal rivers, the Humber, Exploits, Gander, Gambo and Terra Nova. However, the valley of almost every river on the island has stands of merchantable timber of sufficient area to provide habitat for moose.

Good moose range.—Almost the entire pulpwood supply for the pulp and paper industry is produced on range of this classification (Figure 2). Away from the coast 40 per cent of the forest is composed of virgin timber. Mixed stands of balsam fir and white birch are preferred by moose, and the soil site type in which they occur is found in over 75 per cent of the forested areas. Other important features of this range are the muskegs and barrens which are interspersed throughout, comprising almost 40 per cent of the total area. (Anglo Newfoundland Development Company, 1953). These openings greatly en-



hance the value of the range for moose; the edges are favored for bedding sites in summer and for feeding sites in fall and early winter when sweet gale becomes palatable.

Caribou are not common in this range, being found principally on the perimeter.

Marginal moose range.—This range has very large areas of muskeg, barren and water (Figure 2). Forest cover constitutes less than 25 per cent of the total area and is over 80 per cent mature. The dominant trees in the forest association are black spruce and balsam fir, with white birch generally occurring only as a minor stand component. Forest cover is so interspersed along lakes and streams that moose wintering range is found throughout the area.

The most favorable year-round caribou range is found in these areas.

A large portion of the Avalon and Burin Peninsula falls into this classification; however, very little virgin forest exists in either area. The Avalon Peninsula has been subjected to a large number of fires, and forests are just beginning to come back under improved fire protection.

Submarginal moose range.—At an elevation of approximately 1,200 feet forest cover gives way to subalpine tundra which constitutes the greater part of the area in this classification. The only moose range is found along the streams which dissect this mountainous area.

These tundra areas are favored by caribou in summer, however, the animals generally move to lower elevations during the fall migration.

FOOD AND BROWSE CONDITIONS

The shrub and tree species which are the basis of moose diet are essentially the same in Newfoundland as in the remainder of eastern Canada (Murie, 1934; Aldous and Krefting, 1946; Peterson, 1949a), with some variation in the importance of certain species. White birch (*Betula papyrifera*) and balsam fir (*Abies balsamea*) are the two species which are of universal importance. They are followed by fire cherry (*Prunus pennsylvanica*), mountain maple (*Acer spicatum*), mountain ash (*Sorbus* spp.), ground hemlock (*Taxus canadensis*), aspen (*Populus tremuloides*), willow (*Salix* spp.), mountain alder (*Alnus crispa*), sweet gale (*Myrica Gale*), and shadbush (*Amelanchier bartramiana*). Of lesser importance are raspberry (*Rubus idaeus*), red maple (*Acer rubrum*), red-osier dogwood (*Cornus stolonifera*), highbush cranberry (*Viburnum trilobum*), red-berried elder (*Sambucus pubens*), speckled alder (*Alnus rugosa*), and yellow birch (*Betula lutea*). No evidence of browsing on such dominant species as black spruce (*Picea mariana*), white spruce (*Picea glauca*), white pine (*Pinus strobus*), and tamarack (*Larix laricina*) has been found.

I have found it possible to classify browse conditions by the use of three species; ground hemlock, white birch and balsam fir. If ground hemlock is found to be lightly or moderately browsed, the range invariably is below carrying capacity and many palatable deciduous species will be available. White birch is also highly palatable and is found in many early succession sites where ground hemlock is generally absent; if either or both of these species are available in quantity, fir will provide a small percentage of the winter feed. Conversely, if fir is heavily browsed, ground hemlock will be killed out and the palatable deciduous species will be severely overbrowsed, with at least a portion eliminated from the habitat. This classification has been of great value in interpreting reports of browse conditions made by our field staff.

Of the three species, birch is the only one which is browsed by moose during all seasons of the year. Utilization of birch is much more uniform throughout the range than utilization of balsam fir. Browsing on ground hemlock begins after leaf fall and continues as long as it is available. Fir is browsed only in winter and when other palatable species are in short supply. Cover is also an important factor in the utilization of fir, and in overbrowsed areas stands of untouched fir reproduction will be found where no interspersed timbered areas are available to provide suitable escape and winter cover. Such timbered areas are generally residual stands which are below the required diameter limit at the time of the pulp cutting operation.

Moose utilization of white birch, and to a lesser extent of balsam fir, is of economic importance and merits consideration. I have found that in large areas of good moose range, particularly between Corner Brook and Grand Falls, white birch reproduction after 1935 has been heavily utilized. In some particularly favorable moose areas this has resulted in the complete elimination of birch reproduction, in others the birch has been so retarded that it will eventually be shaded out by coniferous species, or hedged so that it will never become merchantable.

The most extensive areas of overbrowsed fir are found in the zone of good moose range and lie principally in the Upper Humber-Indian River watersheds. Other smaller overbrowsed areas are in the central district, and are mainly due to winter concentrations but are not widespread enough to be of a serious nature. Other reportedly overbrowsed areas in this zone occur in the lower Gander River area and in the Red Indian-Lloyd's Lake area. I have not investigated them.

One river valley in submarginal range was found to be so seriously overbrowsed that starvation losses are likely to occur in severe winters. No overbrowsed areas have yet been located in the marginal range zone.

The opening of the highway and the expansion of pulpwood-cutting operations into the overstocked range of the Upper Humber-Indian River area greatly reduced the likelihood of starvation losses. A high annual kill, in one section one animal to three square miles, is affecting the population. In addition the cutting operations are returning many virgin timber stands to favorable early succession stages.

To summarize: The over-all food picture for the island is good; large sections of the range are still below carrying capacity and most of the overbrowsed range is found close to recent cutting operations where favorable range is available.

POPULATION DATA

Two methods are presently being used to gather population data. Moose record cards patterned after those used by Dr. Randolph L. Peterson in Ontario have been in use by the field staffs of the Department of Mines and Resources and of the pulp and paper companies since 1950. In 1952 three trained field parties worked from June until October on field observations. The latter data are considered more reliable than those from moose record cards, for, in addition to their being trained, all party members were equipped with binoculars; they often observed animals for extended periods and committed observations to paper immediately after these were made. Field parties combined information obtained from roadside observations, (made in the early morning and by means of a spotlight at night), from water transects, from field transects and from look-outs in favorable locations.

Sex ratio.—In spite of an alleged bull kill of approximately 14,000 animals in the past eight years, the sex ratio appears to be close to a 1:1 ratio (Table 1).

TABLE 1. SEX RATIOS (MAY 1-NOVEMBER 30)

Source	Year	Bulls	Cows	Ratio Bulls	Ratio Cows
Moose Record Cards	1950	171	213	44	56
	1951	384	351	52	48
	1952	290	228	56	44
	Total	845	792	51.6	48.4
Field Parties	1950	10	6	....	....
	1951	37	29	....	....
	1952	341	430	44	56
	Total	388	465	45	55

Moose record data compiled for 1950-52 give an estimate of 51.6 per cent bulls for the period. The estimate varies between 44 per cent bulls in 1950 to 56 per cent bulls in 1952. The Chi-square test disclosed statistically significant differences between both the 1950 and 1952 bull percentages and the three-year mean. Ontario record card data (Peterson, 1949a) for 1947-48 give a bull estimate of 52.5 per cent with a corresponding variation between 54 per cent bulls in 1947 and 49 per cent in 1948. While there appears to be an annual shift in these record-card sex ratios, it is not possible to rule out increasing or changing bias in the method of recording.

Newfoundland field party results for 1952 (Table 1) give an estimate of 44 per cent bulls, which is significantly different from the 56 per cent bull estimate given by the record cards for the same year.

Wright (1952) combining his data for a three-year period, but not showing annual variation, divides New Brunswick on the basis of browse conditions and gives an estimate of 53 per cent bulls on overbrowsed range and 44 per cent on normal range.

Hatter's data (1950a) for a three-year period in a heavily hunted district in British Columbia, based on guide reports, gives a consistent estimate of 25 per cent bulls.

These comparisons are interesting in that neither the Ontario nor the Newfoundland bull estimates compare with central British Columbia although a bull law is in force in these three provinces. Hatter (1950b) states that the 25 per cent bull cow ratio in the heavily hunted district is the lowest known to exist in central British Columbia, but that there is no positive indication that it has an important influence on the calf crop.

New Brunswick has not had an open season on moose since 1937.

The Newfoundland sex ratio data were largely gathered in the good range zone. While I consider the field party data as a standard, the observations were generally made in the Western and Exploits regions (Figure 3). The record card observations were more evenly dispersed throughout the zone. I do not know what other variables or biases may be present to cause the variation from year to year in the record card data or between the record card data and field party data for 1952. A regional breakdown will be made at a later date, when sufficient data have been gathered, and may help to clarify the situation.

Productivity and age ratios.—Hosley (1949) discusses the general assumption that barren mature cows are common in moose populations. Observations from Isle Royale (Murie, 1934), Ontario (Peterson, 1949a), New Brunswick (Wright, 1952) and from our study (Table 2) all indicate that 50 per cent or more of the adult cows observed are not followed by calves. A third or more of these so-called barren cows are undoubtedly two-year-old animals which are about to breed for the first time; the remainder were not satisfactorily classified in any of the studies mentioned.

Certain of our findings and observations lead me to think that in Newfoundland observers in the field do not see cows with calf in the same proportion that they occur in the population. The following facts have influenced my thinking on this matter: (1) In late August of 1950, after observing a lone cow for some time, I shot her, only to find that she was lactating. (2) A number of lengthy observations of single cows have later proven to be cow and calf, the calf having been

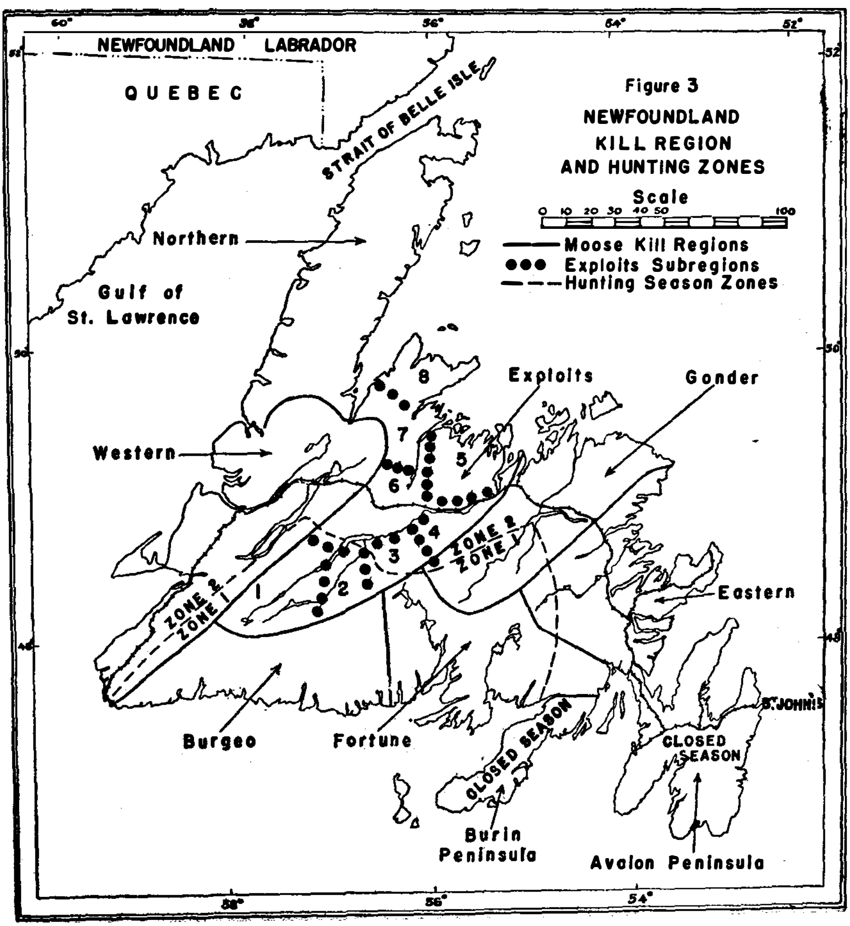


TABLE 2. COW-CALF RATIOS (JULY 1—NOVEMBER 30)

	Moose Record Cards			Field Parties		
Year	Cow	Cow & Calf	Cow & Twins	Cow	Cow & Calf	Cow & Twins
1950	131	64	13	....	....	....
1951	148	112	34	20	9	....
1952	117	59	5	275	115	4
Total	396	235	52	295	124	4

Percentage of barren Cows—58
Cow-Calf ratio 683: 339
2: 1

Percentage of barren Cows—70
Cow-Calf ratio 423: 128
3.3: 1

out of sight for much of the observation period. (Dufresne 1933) suggested that the alertness and habitat preferences of cows with calves are factors in summer calf counts. (3) In 1951 when the trend in cow-calf ratios was more apparent, we decided on a program to obtain more information on adult cow fertility. During that winter we obtained the reproductive tracts from 31 cows. Of the 31, 26 were of breeding age and 23 were pregnant; five contained twin foetuses. This study is being continued and will be reported on at a later date. (4) During the 1952 calving season we conducted a calf mortality study; three field parties covered approximately 250 transect miles in some of our highest density range. On these transects we located one dead calf and the skeletal remains of four from previous years. It is noteworthy that during the investigation we observed more than a hundred moose but managed to get fleeting glimpses of only three calves. As an addition to our calf mortality study 26 members of our warden staff reported two calves drowned in rivers and one calf deserted. If there is a high loss of calves we have not been able to find any supporting evidence. (5) During July, August and September, 1952, our field parties observed 276 cows with a total of 101 calves, and in the same period observed 113 yearlings. The ratio of adult cows to calves during the period was 2.9 :1 and the ratio of adult cows to yearlings was 2.6 :1.

Peterson (1949b) points out the value of yearling data as a measure of the average annual increment to a moose population.

In Ontario, Peterson (*ibid*) found that yearlings comprised 17 per cent of the adult population for an unstated period in both 1947 and 1948. New Brunswick data (Wright, 1952) for the May to September period, give a yearling increment to the adult herd of 14 per cent. These estimates were both based on moose record card data.

In the 1952 field party data (Table 3) yearlings comprise 18 per cent of the adult herd; moose record data for the same period show a yearling increment of 17 per cent. Variation for the three-year

TABLE 3. YEARLING PERCENTAGES (MAY 1 - SEPTEMBER 30)

Year	Moose Record Cards Total Adults	Total Yearlings	Yearling Percentages	Field Parties Total Adults	Total Yearlings	Yearling Percentages
1950	210	21	9.1	16	1	......
1951	569	87	15.3	56	12	17.6
1952	365	76	17.0	613	140	18.5
Total	1,144	184	13.9	685	153	18.2

period is shown in Table 3. The low percentage of yearlings in 1950 may possibly be attributable to observers at first being uncertain of this classification. I consider the yearling estimate the most uncertain statistic and particularly so in the moose record card data where few observers had the aid of binoculars and were untrained at making this classification. Our consideration of increment to the herd is based on field party data.

However, for this statistic to be valid I feel that certain standards should be adhered to in collecting and handling the data. The qualifications are: (1) the capabilities of all observers should be known, (2) only data gathered in the period May 1 to September 30 should be considered, because after that time the classification of yearlings, and especially of females, is very difficult even to experienced field men.

OPEN SEASONS AND KILL RECORDS

Since the law permits the killing of one bull moose or of one stag caribou per license, both species will be considered in part of the discussion of kill data.[1]

Open seasons and license fees.—In 1936 an open season on big game was declared with a license sale restricted to 80. This was the first open season on moose since their introduction and the first on caribou since 1925. Table 4 shows the license sale and the kill during the period 1936 to 1951. From 1945 to 1951 there were two open seasons annually, the early season for the month of September and the late season during the months of November and December. In 1952 a shortened season and a zoning system (Figure 3) were introduced. The island was divided into two zones. In Zone 1, which was located in the southern portion of the island, the two open seasons continued, the first from September 15 to October 10, and the second for the month of December. In Zone 2, the northern portion of the island, the early season was abandoned and the late season was shortened to the month of December.

[1]In Newfoundland a mixed nomenclature for caribou sex is used. Males are referred to as stags, according to the European custom, and females as does, according to the North American.

Zone 1 contains no public roads and less than one hundred miles of private motor roads. Zone 2, exclusive of the Northern Peninsula, contains over 1,500 miles of public and private motor roads.

The resident license fee is 25 dollars for the early season and 5 dollars for the late season. A license may be obtained for either of the two seasons but not both. The high fee has been a factor in the small number of resident hunters during the early season. The non-resident license sale has never exceeded 500, but is gradually increasing.

License sale and reported kill.—The legal moose kill during 1936 to 1944, the period of restricted license sale, reached its peak in 1944 at 145 moose (Table 4). The license sale increased from 2,475 in 1945 to 8,660 in 1951, and the reported kill from 747 moose and 113 caribou to 3,383 moose and 308 caribou. After the kill records were completed for the 1951 season, the zoning system (Figure 3) and shortened seasons were introduced in an attempt to stabilize or lower the moose kill in the good moose range and to concentrate the kill on both moose and caribou in the inaccessible southern section. Records for the 1952 seasons are incomplete; however, it appears that the kill will be lower; the license sale dropped from 8,660 in 1951 to 6,291 in 1952. The reported kill for the year now stands at 2,331 moose with 73 per cent of the returns in. We do not expect the kill to exceed 2,800 moose for 1952.

Hunters' returns.—A great deal of credit is due the Chief Game Warden and his staff for the manner in which they have made Newfoundland's hunters conscious of their obligation to make a return. Since 1945 the percentage of reporting hunters has been 90 per cent or better for all but two years (Table 4). This has been accomplished by means of repeated radio appeals after the close of the hunting sea-

TABLE 4. HUNTING SEASON AND KILL DATA

Year	License Sale Limit	Licenses Issued	Per Cent Returns	Hunter Success	Reported Kill Moose	Reported Kill Caribou	Adjusted Kill Moose	Adjusted Kill Caribou
1936	80	33	100	....	8	6	......	......
1937	80	65	100	....	16	14	......	......
1938	80	82	100	....	17	14	......	......
1939	80	80	100	....	29	11	......	......
1940	100	100	100	....	48	20	......	......
1941	300	234	100	....	45	95	......	......
1942	300	214	100	....	111	25	......	......
1943	300	291	100	....	117	35	......	......
1944	300	296	100	....	145	24	......	......
1945	No limit	2,475	98.5	35	747	113	753	114
1946	"	3,845	90+	....	1,213	159	......	......
1947	"	5,048	90+	....	1,476	193	......	......
1948	"	6,021	87	44	2,081	232	2,239	250
1949	"	5,931	75	49	1,937	221	2,264	257
1950	"	7,240	90	45	2,686	242	2,836	255
1951	"	8,660	94	45	3,383	308	3,492	318

son, and by at least two follow-up letters to each nonreporter. When the percentage of reporting hunters dropped to 75 in 1949, the field staff of the department conducted a personal interview of a 20 per cent random sample of nonreporters (Table 5).

TABLE 5. HUNTERS' RETURNS, 1949

Licenses		Interviews	
No. issued	5,931	No. attempted	302
Returns Received (75%)	4,413	No. interviewed (65%)	195
No. reports (25%)	1,518	Not located (35%)	107
No. Successful Hunters		No. Successful Hunters	
Moose	1,937	Moose	50
Caribou	221	Caribou	2
No. Unsuccessful Hunters	2,255	No. Unsuccessful Hunters	143
Percentage of Successful Hunters	49	Percentage of Successful Hunters	27

In 1950, when the percentage of returns rose to 90, a survey of the nonreporters was again attempted. However, it was unsuccessful, as more than 75 per cent of the nonreporters could not be located. Due to the difficulties encountered in making this type of survey where there are so few roads, we decided to conduct future surveys only when the percentage of returns dropped below 90, and to make an arbitrary adjustment for the other years.

Adjusted kill data.—The 1949 survey confirmed our suspicion that the usual practice of making equiproportionate additions for nonreporting would overcompensate. In that year 49 per cent of the reporting hunters were successful, while only 27 per cent of the nonreporters interviewed were successful. On the basis of this survey the data have been adjusted for the period 1945 to 1951, exclusive of 1946 and of 1947,[2] according to the following formula:

$$\text{Nonreported kill} = \frac{\text{Hunting success of reporters}}{2} \times \text{No. nonreporters.}$$

This additional kill is then allocated to moose and caribou in the same proportion that they comprise the kill for the year. While the adjustment is somewhat arbitrary in nature the magnitude of possible error would appear to be very small in the final estimate.

Discussion of kill.—Although a bull law has been in force since the first open season in 1945, proof of sex of kill has never been required. In the discussion of kill data it cannot safely be presumed that the kill is of bulls only. Casual interviews in the course of my study first led me to believe that quite a high cow kill was actually occurring in

[2]Unfortunately the indexes for 1946 and 1947 were misplaced and the data cannot be adjusted for these years.

TABLE 6. REGIONAL KILL BREAKDOWN—SQUARE MILES PER KILL

Region	Area	1945	1946	1947	1948	1949	1950	1951	Average Kill 1945-51	Av. 45-51	1951
Northern	5,900	4	21	70	105	128	146	54	75	79	109
Western	5,800	279	423	507	567	490	623	888	539	11	6.5
Exploits	7,300	263	399	359	606	582	770	1,068	578	13	6.8
Gander	3,100	62	97	124	266	253	322	485	230	13	6.4
Eastern	4,300	88	161	249	341	293	544	585	322	13	7.4
Fortune Bay	4,400	32	85	144	178	163	222	214	147	30	21
Burgeo	4,200	8	16	19	18	28	50	54	28	150	78
Unknown		11	11	4	0	0	9	35		....	....
Total	35,000	747	1,213	1,476	2,081	1,937	2,686	3,383	1,919	18	10

many areas. Some proof of this is offered by the following: (1) In a hunting season study conducted in an area where 93 kills were made, 23 kills were located, 8 of which were found to be cows. Admittedly, this is a small sample but it indicates that a comparatively high cow kill may be occurring at least in some areas. (2) Observed sex ratios in some areas of high kill investigated approached a 1:1 ratio.

Table 6 gives the breakdown of the kill on a regional basis for the period 1945 to 1951. It can be seen that kills of approximately the same magnitude are occurring in the western, Exploits, Gander, and eastern regions with the kill in the Gander region reaching the highest density with an average kill of 1 moose for 6.4 square miles in 1951. A complete breakdown of the range into subregions for 1951 has shown that the kill is far from uniform. As an illustration, the breakdown of the Exploits region into 8 subregions is shown in Figure 3, and the average kill figures are given in Table 7. The greatest variation within the Exploits region existed between the Sandy and the Baie Verte subregions, with a kill of 1 moose to 2.7 square miles in the former, and of 1 per 388 square miles in the latter. In the Baie Verte the low kill is largely a density factor while in Annieopsquotch it is mainly due to accessibility.

Data computed by Peterson (1950a) for Sweden for 1946 (Lubeck, 1947), and for Nova Scotia for the period 1908 to 1937 (Department

TABLE 7. KILL BREAKDOWN EXPLOITS REGION—1951

Subregion	Area	Kill	Square Miles Per Kill	Kill Per 100 Square Miles
(1) Annieopsquotch	1,850	20	92.0	1.1
(2) Noel Paul	600	200	3.0	33.3
(3) Sandy	630	149	4.2	23.7
(4) Rattling Brook	710	293	2.4	41.2
(5) Badger-Millertown	1,120	195	5.7	17.4
(6) Notre Dame	780	102	7.6	13.8
(7) Hall's Bay	960	107	9.0	11.1
(8) Baie Verte	650	2	325.0	.4
Total	7,300	1.068	6.6	14.6

of Lands and Forests, 1943), offer a comparison with Newfoundland kill densities. On approximately one-half of the moose range in Sweden the kill varied from 1 moose to 2 square miles to 1 moose to 10 square miles. On a third of the range it varied from 1 moose to 11 square miles to 7 moose to 77 square miles. On the other sixth of the range it was 1 moose to 405 square miles. In Nova Scotia, with a bull law in force, the highest kill for any county was 1 moose to 5 square miles over a 1,285 square mile area in 1926; a kill of 1 moose to 15 square miles was much more common for the period. There have been no open seasons since 1937.

On an area basis the kill of moose in Newfoundland in 1951 approaches that of Sweden.

RANGE CONDITIONING FACTORS

Forestry operations, fire, and climate are the most important variable factors which affect the carrying capacity of moose range.

Forestry program.—The two pulp and paper companies have outright ownership, or long-term leases, on over 18,000 square miles, which includes approximately three-quarters of the productive forest lands (Gutsell, 1949). The other quarter is under Crown ownership and includes the forests in a three-mile belt around the entire coast. The forests of this coastal belt supply fuel and lumber to the local populace; they are largely cut over, and tend to be permanently maintained in immature stages by repeated cutting. Elsewhere on accessible Crown lands small sawmill operations are widely interspersed. The small openings created in the forest by these operations contribute much to the value of the range for moose.

The wood requirements of the pulp and paper industry necessitate the annual harvesting of over a hundred square miles of productive forest land or between one and two per cent of the forests in the good range zone. These cut-over areas are of great importance to the moose population and are an important reason for the high carrying capacity of the good range zone.

There are several favorable features of the cutting programs of the two companies which are worthy of discussion: (1) In the good range zone there are 13 pulpwood operating districts. It can be seen from Fgure 1 that these are well distributed throughout the zone. (2) Within each district cutting operations are generally well dispersed so that early forest succession stages may be found scattered throughout well-forested areas. In addition, the operations in any one subdistrict often are not of a continuous nature, and may be moved to new areas before a complete cutover is made. This generally results in an ideal interspersion of food and cover. (3) In the actual cutting operations small camps averaging approximately 4,000 cords a year are most common; this means that the average area cut over by a camp is less than one-half a square mile. The denudation of an area proceeds so slowly that moose are seldom forced to make population shifts in their wake. (4) Although a clear-cut type of operation is used, residual patches of immature undersized timber which have resulted from blowdowns or fires are left. These provide the cover necessary for the winter use of many cut-over areas when they are in the highest food-producing stage.

Forest fires.—Complete records of fire history are difficult to obtain prior to 1944. Fires during the period 1944 to 1952 burned 900 square miles, approximately half of which was productive forest land. This is an average of 40 square miles annually (Newfoundland Forest Protection Association, 1952). Many of these fires were small and resulted in favorable habitat changes for moose.

Climate.—While the winters tend to be long, temperatures are not extreme and rarely go below —10° F. for much of the island. Snow conditions are seldom extreme enough to force animals to remain in limited areas for long periods. Mild winters frequently occur when it is possible for the animals to utilize shrub species such as sweet gale and ground hemlock for long periods.

SUMMARY

1. Newfoundland's big-game research program began in 1950. Initial efforts are being concentrated on moose.
2. A bull and a cow moose were first introduced in 1878. The second introduction of three bulls and four cows was made in 1904. By 1945 the entire island was populated.
3. The over-all food picture for the island is good; large sections of the range are below carrying capacity and most overbrowsed areas are in areas where recent pulpwood cutting operations have made favorable range available.
4. Sex ratios are close to 1:1. Observed cow-calf ratios are low; however certain facts indicate that cows with calves are not observed in the same proportion that they occur in the population. Yearling-adult ratios are approximately 1:5.
5. The total reported kill for 1951 was 3,383. Kills of 1 moose per 4 square miles were common in a number of regions.
6. Shortened seasons and a zoning system introduced in 1952 appear to have reduced the kill to approximately 2,800.

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DISCUSSION

DR. DEVOS: Thank you, Mr. Pimlott.

Mr. Pimlott's remarks about the food habits are of interest. Aspen, which he mentioned as number four on his list, usually has a higher rate on the mainland. Ground hemlock, while a key species in Newfoundland, has disappeared from many parts of the mainland, likely because of overbrowsing.

An important finding for moose management is that observers in the field do not see cowless calves in the same proportion that they occur in the population.

The fact that, on an area basis the kill in Newfoundland in 1951 approaches that of Sweden, may indicate that, under a good forest-management system, much higher harvests might be obtained on the mainland.

Now we are running a bit short of time. I would like to cut the discussion short to approximately five minutes. Anyone who wishes to comment on this paper?

DR. PETERSON: I would like to make one or two questions. First of all, I was quite interested in your observation about the relationship of balsam fir and ground hemlock. Is it your impression that, in the areas where ground hemlock is available, it is much preferred over balsam fir?

MR. PIMLOTT: That is very true. I am sorry I did not make that clear. Ground hemlock comes into use in the early fall or about the time of leaf fall. It is then a favorite species throughout, as long as it is available above the snow. However, I find no evidence of its use in summer. It seems to become a favorite palatable after the leaf fall.

DR. PETERSON: Yes, that is sort of leading up to the next question I was going to ask you. Ground hemlock, I believe, has been reported as having been fed year around; whereas balsam fir, at least in our experience, is strictly a winter diet, and is not eaten at all. I am wondering if perhaps that had any bearing on your observations, whether the low utilization of balsam was summer-feeding evidence or during winter.

MR. PIMLOTT: I have found no utilization of balsam fir whatsoever during the summer season.

The earliest observation I have made of browsing on balsam firm was about the end of September, in severely over-utilized range. I found areas where balsam fir has been virtually untouched, although you could walk through these stands and you would have difficulty finding a single birch which had not been clipped or killed.

DR. PETERSON: That was all winter work, you feel, on the deciduous species?

MR. PIMLOTT: Oh, no. The browsing on birch is very uniform throughout the range, because it is utilized twelve months of the year. Browsing on balsam fir is very spotty, because of the winter nature of the browsing, and the fact that it is only utilized mainly when other palatable deciduous species are in short supply.

DR. PETERSON: Leading up to that point, in our work in Ontario we were quite struck with the high utilization of balsam, both from our field studies and from stomach analyses. In the winter months, we failed to find a stomach in Ontario which did not have balsam in it, and usually in a high per cent.

The last question I was going to ask was about the relationship between moose and caribou. I feel you have an opportunity to give us something on that ecological relationship which should be very difficult to obtain in other places. I was wondering if, in the present state of your research, you had formed any conclusions on the relationships themselves between those two species. In other words, is the caribou faring just as well now as it ever has?

MR. PIMLOTT: I think the caribou populations are considerably lower than they were in primitive time. I do not, however, feel that this is directly related to moose.

Whenever you have a road going through caribou range, you immediately find a drop-off in the caribou population.

At the present time, moose are important as a buffer species for caribou. Our legal-kill figures for caribou, I think, represent at least 95 per cent of the total kill. In other words, there is virtually no poaching on moose at the present time, and a very low legal kill. This is because moose are available in the areas where they are needed by the public. So, at the present time, moose is an important buffer species for caribou.

In this marginal-range zone, we do have a wintering population of moose. Moreover, my limited observations in this area indicate that the animals are occupying separate niches; in other words, the caribou winter range is around the edge of the timbers, which are mainly a moose association which will not be inhabited by moose in the wintertime; while the stands which are back from the edge or have the higher percentage of balsam fir are more commonly used by the moose.

I have found very little evidence of competition between the two species up to the present time. However, we are considering a food-habitat study of both moose and caribou in this marginal-range zone.

MR. CHATELAIN: In Alaska, we have found that, due to snow and other range conditions, our winter range is very, very restricted as compared to our summer range. Is such condition true in Newfoundland?

MR. PIMLOTT: It is not entirely true, and I think that highlights the differences in Alaska range and in Newfoundland range.

Virtually all of our summer range can be inhabited by moose in winter, with the exception of the large openings which occur after large-scale fires or in the larger bogs.

I would say that this winter, in the forested areas, there was at least a 90 per cent use of the total range.

A STUDY OF DEERYARD CARRYING CAPACITY BY CONTROLLED BROWSING

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INTRODUCTION

Carrying capacity experiments on northern Michigan deeryards have been in progress at the Cusino Wildlife Experiment Station from 1936 to the present. Davenport *et al.* (1944) summarized the work done on the project during the pre-war years. Since that time several years of additional data have been collected after the studies were suspended because of the war. Although the objectives of the experiments were described in the original paper, they are repeated here for the benefit of those not familiar with the earlier work.

The principal objectives were to determine (1) the amount of acceptable and available browse per acre in different types of winter deeryards in northern Michigan, and (2) the sustained carrying capacity per acre of yard. Because the first objective was largely realized in the earlier years of the project, the second has been emphasized in more recent work.

Varying numbers of deer were placed in one-acre fenced plots in the Cusino deeryard, located in the north central part of the Upper Peninsula of Michigan. The number of deer varied during different times in the same year and varied from plot to plot. The area studied is in a deep-snow belt, with annual maximum snow depths ranging from approximately two and one-half feet to well over five feet. The natural yarding season for deer in this area was considered to average approximately 90 days. The amount of available browse was measured by cruising the plots in the fall before deer were introduced and again in the spring after the deer were removed. Carrying capacity of the plots was determined by evaluating browse availability in relation to deer losses and to the condition of the confined deer at the end of the yarding season.

The utmost care was necessary in selecting the experimental plots to assure that they would represent the different combinations and types of browse plants common to northern Michigan deeryards. Since at the outset we were endeavoring to determine the actual amount of usable browse on an acre basis, it was necessary to select plots having the maximum availability of that particular type and browse species combination. All of the plots were located in unbrowsed portions of typical deeryards in the area under study. Before deer were placed in the plots, cover analysis strips one chain (66 feet) long and one-tenth of a chain wide were laid out, so that a five per cent sample cruise could be made. The number and size of stems of each species was recorded and the browse rated according to the amount of each species available.

The latter rating was based on a comparison between a plant in the plot and a similar unbrowsed one growing in the open. Only browse below six and one-half feet was considered available to deer. Browse availability was rated in four categories: (1) no browse, (2) 1 to 33 per cent, (3) 34 to 66 per cent, and (4) 67 to 100 per cent. The browse rating method used was a relative one and admittedly subject to some human errors but was thought to be the most practical that could be devised at the time.

Most of the deer used in the plots were wild-trapped, although in the early part of the experiment corral-reared deer were used in a few cases. Age and sex ratios of experimental deer for the most part were close approximations of those of the wild herd. Each introduced deer was weighed and its condition noted in the fall and again in the spring on removal from the enclosure. Animals that died in the plots were carefully examined to determine the exact cause of death.

HISTORY OF THE PLOTS

Twelve plots were in use intermittently during the course of the experiments. The greatest gap in our records resulted from complete suspension of the project in the five-year period between 1942 and 1947, and again in the winter of 1949-50. Although in some respects this lack of continuity might be considered unfortunate, it did serve to provide additional information on the changes in browse conditions resulting from a temporary retirement from browsing.

Plot No. 1.—This plot appeared superficially to be a nearly pure stand of swamp conifers. This was caused by the relatively large size of conifers which obscured to some degree the understory of hardwoods and shrub species. The initial cruise in the fall of 1936 showed that 38 per cent of the stems were white cedar (*Thuja occidentalis*), 5.3 per cent balsam (*Abies balsamea*), and spruce (*Picea glauca* and *P. mariana*), 15.2 per cent palatable hardwoods including red maple (*Acer rubrum*), birch (*Betula lutea* and *B. papyrifera*), and red osier dogwood (*Cornus stolonifera*), and 41.5 per cent speckled alder (*Alnus rugosa*) and highbush cranberry (*Viburnum trilobum*), neither of which was considered palatable to deer. There were smaller amounts of black ash (*Fraxinus nigra*), and a few hardwood shrub species, several of which increased in abundance after several years of browsing.

Eight deer were introduced into this plot in the winter of 1936-37 and the plot was browsed 592 deer-days. At the time the deer were removed in the spring it was estimated they had consumed 60 per cent of the available browse. During the next three years five deer were placed in the plot each year, subjecting it to 373, 439, and 388 deer-days of browsing, respectively. All deer, except one which died in 1938-39 and one which apparently escaped in 1939-40, were released in the spring with average weight losses varying from 22 to 24 per cent.

In 1940-41 five deer were again placed in the plot but only two survived the winter. The average weight loss in the five was 34 per cent, which controlled feeding experiments have shown is approximately four per cent higher than the maximum that will permit survival. The plot was subjected that year to 426 deer-days of browsing and was believed to be completely browsed out, having sustained by the end of winter 2,216 deer-days of browsing in five years. In 1941-42, because of its apparently browsed-out condition, only one deer was placed in the plot, and surprisingly enough came through the winter in good shape. From the data collected, it was estimated that this plot during its period of greatest browse production would carry two to three deer each season on a sustained basis.

In 1947-48, the first year the plots were used after the war, two deer were confined, since the fall cruise indicated that some regeneration of browse had occurred and might support that many deer. However, both of these animals succumbed from malnutrition after only 99 deer-days of browsing. In 1948-49 two animals again were placed in the plot. These deer were released later with an average weight loss of 3.2 per cent after only 50 deer-days of browsing. Cruise data for that year are missing, but it was obvious from general observations that browse had not regenerated to a point where the two animals could survive the winter. After a lapse of one year in which the plot was not used, the fall cruise of 1950 showed some improvement in browse conditions and two deer were again confined. Both deer came through the winter with weight losses of 16.6 per cent and 16.8 per cent, respectively, after 191 deer-days of browsing. The fall cruise of 1951 showed that although the two deer survived the previous winter, the browse had deteriorated. It was now decided to subject the plot to heavy browsing to find how long it would take to browse it out and then clear-cut it to study regrowth following cutting. Accordingly, four deer were introduced and browsed a total of 213 deer-days, with a loss of two animals and an average weight loss of 19 per cent in the two that survived. The plot was now considered browsed out and was clear-cut as planned in the fall of 1952.

This plot has had a 12-year history of overbrowsing and at several times has been considered completely browsed out. Yet it has continued to carry as many as two deer per season under that condition.

Plot No. 2. This plot is considerably different from the others, being located in a dense stand of hardwood reproduction. The initial cruise in 1936 showed hard maple (*Acer saccharum*) predominating, with 88 per cent of all stems. The remainder of the stems consisted of beech (*Fagus grandifolia*), northern hazelnut (*Corylus cornuta*), yellow birch (*Betula lutea*), and balsam. During the first winter the five animals that were placed in the plot browsed it a total of 171 deer-days. It soon became evident that they would not be able to survive the winter, and by the time they were to be released in the spring three had died, with an average weight loss of 21 per cent. It was estimated that available browse had been reduced by 95 per cent. Feeding experiments subsequently demonstrated that although very palatable to deer, hard maple alone does not provide the essential nutrients to carry deer in the best of condition through the yarding season.

When the fall cruise of 1937 showed very little reproduction the scope of the work in this plot was altered somewhat to include a study of artificial deer feeds. "New York Deer Cake," consisting of a combination of soybean meal and molasses, was fed the following two winters, and all deer confined in the plot came through both winters in excellent condition.

The fall cruise of 1939 showed that browse had further deteriorated after the heavy browsing of the past three winters. To measure the amount of food available one deer was confined in the plot but lived only 15 days. It was thus evident that this plot was not capable of carrying deer without supplementary feeding.

The plot was then clear cut with the purpose of determining how long a period would be required for regrowth to provide a usable food supply. Shapton (1946) pointed out that the annual growth rate of new browse in this plot appeared to be 8 to 12 inches a year, and believed that by the yarding season of 1944-45 new stems of hard maple resulting from sprouting would cause the plot to reach its maximum productivity. Intervention of the war prevented the experiments from being continued during the years when this would have been expected to occur, and as a result most of the foliage had grown out of reach by the fall of 1950. Two deer were placed in the enclosure the following winter and browsed a total of 23 deer-days, after which they escaped through a hole in the fence. Although data for this year were largely lost as a consequence, it was believed that not enough food was available in the plot to sustain two deer per winter.

In the following fall (1951) one deer was introduced but died before the end of the yarding season, even though the winter was milder than normal. Browse in the plot had now reached the lowest point of availability since the pre-war years, and it was decided to clear-cut it in the spring of 1952 in another effort to determine how much browse would result from cutting. One deer was introduced early in the winter of 1952-53 to find out if enough reproduction had come in during the past growing season to carry one animal. By mid-winter it appeared that it would not be able to survive on the new growth, which had been either consumed or covered by snow.

Information collected on this plot clearly demonstrated that the carrying capacity of a hardwood type of this density and species composition is considerably lower than the conifer plots described elsewhere in this report. Although the cruise data showed a fairly high browse production on the basis of a comparison with other stems of hard maple growing in the open, the actual browse produced and available to deer was relatively low. When the plot was first cut in 1941, the browse was fed to deer in connection with the controlled feeding experiments then in progress. It was found that the plot yielded less than 500 pounds of edible browse. It was evident that the sustained carrying capacity of this forest type probably would be less than one deer to an acre during its years of peak browse production.

Plot No. 3. This plot is similar to No. 1 in type except that it contains a greater variety of palatable and nutritious hardwoods, consisting principally of shrub species that provide a large amount of available browse. The initial cruise showed white cedar predominating with 49.4 per cent of all stems. The remainder of the stems were 7.5

per cent non-palatable conifers, 28.3 per cent non-palatable hardwoods, and 14.8 per cent palatable hardwoods. Five deer were confined in this plot in 1936 and browsed a total of 387 deer-days. The spring cruise showed less than 40 per cent of the browse utilized. During the succeeding four winters four deer were confined, and with the exception of one animal which died of infection, all came through in fair to good condition. In 1941-42 four deer again were placed in the plot, but one failed to survive until spring. This plot had now been subjected to 2,163 deer-days of browsing in five years, and it was evident from the latest cruise and by observation that it should carry two to three deer to an acre on a sustained basis for an indefinite period.

Because of the mechanical difficulties involved in working with this plot after the Station headquarters were relocated, studies in it have now been abandoned and it is not expected they will be resumed in the near future.

Plot No. 4. This plot is similar in composition to Plot 1, with 45 per cent of the stems being white cedar, 13 per cent palatable hardwoods, and the remainder non-palatable hardwoods and conifers. Four deer were placed in the plot in the winters of 1937-38, 1938-39, and 1939-40. After being browsed a total of 979 deer-days during the three-year period, it was evident that this browsing pressure was above the carrying capacity of the plot. In 1940-41 four deer survived to the end of the yarding season but lost 30 per cent of their weight, which is the maximum amount that it is believed can be lost and still permit recovery in the spring. Four animals again were placed in the plot in 1941-42 but only one survived the winter.

The plot was not used again until the season of 1947-48, when the fall cruise showed that some regrowth had occurred during the five years it was not browsed. Two deer were confined that winter, but one of them died from malnutrition before spring. One of two deer again succumbed in the winter of 1948-49. After one year's absence of deer, available browse appeared to be increasing by the fall of 1950 and three deer were confined in early winter. Unfortunately, all three escaped after having browsed a total of only 162 deer-days. Subsequent cruises and observation showed that browse availability remained at a fairly high level, and the number of deer therefore was increased to four in 1951-52 to see what the plot could withstand. After 320 deer-days of browsing the plot was considered browsed out, and it was evident that browsing by three deer to the acre was above the sustained carrying capacity of this type. It was believed that this plot during its years of maximum production could carry two deer to the acre on a sustained basis, but that in its present condition probably could not support more than one per acre. The plot, along with Plot 1, was then clear-cut of merchantable materials in the fall of 1952.

Plot No. 5. Plot 5 is one of four one-acre plots constituting a four-acre enclosure. The cover type in all of these is comparable to Plot 1 but varies considerably as to density. All have been subjected to deer browsing since their construction in 1938, except No. 7 which has been used as a control. Plot 5 had been browsed by three deer each winter from 1936 through 1941-42. In the spring of 1942 one deer died of malnutrition and it was apparent at the end of the yarding season that three deer to the acre was somewhat above the sustained carrying capacity of the plot.

After five years of no browsing, available food had increased slightly, but inasmuch as the plot would not carry three deer to the acre previously, only two deer were confined in the winters of 1947-48 and 1949-50. During these two years the plot was subjected to 122 and 55 deer-days of browsing, respectively, with two deer dying of malnutrition the first winter and one the second winter.

Because of an observed improvement in food conditions after a one-year retirement from browsing in 1949-50, two deer were placed in the plot in early winter of 1951, but unfortunately both escaped within a few days. These animals were immediately replaced by two others, so that by the end of the yarding season the plot had been subjected to approximately 180 deer-days of browsing. This amount of browsing appeared to be above the present carrying capacity of the plot as shown by the fall cruise of 1951 which indicated a further deterioration in available browse. Accordingly, in 1951-52 only one deer was confined for a period of 54 days, during which it lost 20 per cent of its weight, and browse continued to deteriorate. From the above data it appears that this plot will not carry more than one deer per acre on a sustained basis in its present condition.

Plot No. 6. At the start of the experiments in 1938-39 this plot was subjected to an extremely high concentration of deer to determine how much browse was available and usable. Ten deer were confined that winter, and although one animal died early in the season, the remainder came through with an average weight loss of 22 per cent. The following winter five deer were confined, but only one survived. The spring cruise showed nearly all browse gone, and it was evident that the plot had been browsed beyond the point where it would support that many animals. In 1940-41 two deer were introduced but failed to survive the winter. In 1941-42 one deer lived, even though the plot had been considered completely browsed out since 1941.

Following the war years, two deer were confined in the winter of 1947-48, but failed to survive until spring. In 1948-49 two deer again were placed in the plot but one died from malnutrition, and one lived but lost 11 per cent of its weight. Losses of animals occurred in those two years even though the plot was subjected to an average of only 54 deer-days of browsing each year, or about one half a deer per season.

The fall cruise of 1950 showed that browse had regenerated to a level which it was estimated might carry two deer to the acre in 1950-51. Two animals were placed in the plot in early winter and both came through in fair shape after 186 deer-days of browsing. Four deer were confined in 1951-52, but only one lived and it lost more than 20 per cent of its weight. After 199 deer-days of browsing this plot was believed to be nearly browsed out, and it was obvious that in its present condition it would not carry more than one deer to the acre on a sustained basis.

Plot No. 7. This is the control plot of the group including Plots 5, 6, and 8. With the exception of one deer which broke into the enclosure in the yarding season of 1949 from Plot 8 and browsed over a period not exceeding 32 days, it has not been browsed by deer. A definite downward trend in the amount of usable browse was noted from the time the plot was established in 1938 to the present. It appears that browsing by snowshoe hares, self-pruning, and possibly some loss in reproduction caused by shading, have been the most important factors cutting down browse production through the years. This was especially true in later years after the conifers and other trees began to approach maturity.

Plot No. 8. Plot 8 has been browsed by two deer per winter during its entire history, and is the only plot discussed thus far that has been subjected to a browsing pressure which it was estimated at the time should be near its sustained carrying capacity. All deer survived the first four winters but weight losses increased slightly each year. In 1947-48, after a five-year retirement from browsing, the plot still had not recuperated sufficiently to carry two deer. In both years one of the two deer starved, and the available browse continued to decrease.

As in most of the other plots the fall cruises in 1950 showed a slight increase in the amount of browse available. Two deer confined in early winter escaped after several days and were replaced by two other animals, one of which escaped just before the end of the yarding season. As nearly as could be determined the total deer-days of browsing by these four animals was approximately 174. In 1951-52, 115 deer-days of browsing by two deer almost completely browsed out the plot with one animal having starved and the other having lost 24 per cent of its weight. The 1952 fall cruise showed a very slight regeneration of browse, but it was believed on the basis of the above data that the sustained carrying capacity of this plot in its present condition would not be above one deer to the acre.

Plots 9, 10, 11, and 12. These plots were constructed as a group of four in 1941 in a conifer swamp of which cedar was the principal and only palatable species existing in any quantity. The stand is somewhat older than that of the Cusino swamp plots, and because of the larger size of the trees there appears to be more available browse. Due to the complete suspension of Station activities at the start of the war, these plots were not put into full operation and no significant data were collected until work was resumed in 1951. For all practical purposes, it can be considered that studies in these plots did not begin until the fall of that year.

Plot No. 9. The first post-war cruise of 1951 showed that white cedar comprised 88.5 per cent of all stems, while balsam, spruce, alder, and a very small amount of ground hemlock (*Taxus canadensis*) made up the remainder. Early in the winter of 1951-52 two deer were introduced and the plot was subjected to 132 deer-days of browsing. At the end of the yarding season it was estimated that available food was decreased by one half. The fall cruise of 1952 showed that browse conditions improved somewhat during the intervening growing season, but it appears that such mature cedar stands will not be able to carry more than one deer per acre on a permanent basis.

Plot No. 10. Species composition of this plot by percentage of stems was 89.4 per cent cedar, with balsam, spruce, and an insignificant amount of tamarack (*Larix laricina*). Usable cedar browse in this plot appeared to be abundant, but after being subjected to 194 deer-days of browsing by three deer in 1951-52 it was estimated that more than one half of the available browse had been consumed. In this plot also, available browse increased by the fall of 1952, although at present it seems likely that the sustained carrying capacity will not be more than one deer per acre.

Plot No. 11. This is now the control plot, and with the exception of the browsing that occurred in 1941-42, it has not been browsed to any degree since then. By species composition it included 89.2 per cent cedar with the remainder in alder, balsam, spruce, and a very small amount of tamarack. Initially there was no great difference in species composition and total browse availability between this plot and the three that are being browsed.

Plot No. 12. Plot 12 contained 82.7 per cent cedar, which is a slightly smaller proportion than in the other plots of the group, but included the same non-palatable species, namely spruce, balsam, and alder. When subjected to 81 deer-days of browsing in 1951-52 it was found that about two-thirds of the available browse was used up. Less regeneration of browse in the fall of 1952 was noted in this plot than in the three others. The above data suggest that some factor, possibly the somewhat smaller amount of usable cedar, is operating to hold this plot's carrying capacity below that of the others, and on a sustained basis it may not carry one deer per acre.

The cruises in these plots clearly show that they are essentially "one diet" plots, with white cedar being the only food species of any importance. All other species recorded, except for a very small amount of ground hemlock in Plot 9, could be classed as nonpalatable and usually would be eaten only in times of greatest food scarcity. The mature cedar itself in the plots presents a deceiving picture. Because of its large size and abundance of foliage in the canopy it appears to furnish a considerable amount of food. Much of the reproduction, available only at times of minimum snow depth, is covered during the greater part of the winter in this area. It is evident in all of these plots that cedar has grown beyond its maximum carrying capacity for deer and that not enough reproduction has come in, possibly because of the same factors that operated to cut down available browse in Plot 7, to furnish an abundant food supply during those periods when it is most needed. Probably the only way that food production can be improved in a cedar stand of this age is to remove the larger stems so reproduction will be encouraged.

DISCUSSION

After the carrying capacity experiments had been in progress for several years it became apparent that certain objectives would have to be modified, because it was found impossible to refine our methods of measurement and evaluation to a point where they would produce consistent results. The method of browse evaluation utilized was probably as practical and as accurate as any that could be devised when the experiments were inaugurated, but unquestionably was subject to a number of errors common to any method in which the factor of human judgment is so closely involved. One of the great needs in any browse evaluation technique is to be able to express total browse availability in a given area by a simple figure that can be comprehended by everyone concerned. Some thought was given to this phase of the present studies but thus far no wholly satisfactory method has been formulated.

Considerable difficulty was experienced in predicting the sustained carrying capacity of a plot after the plot had been browsed out. This was due to the slow growth rate of the dominant cedar and some hardwoods which prevented them from recovering under almost any degree of browsing. It might be possible eventually to evaluate better the sustained carrying capacity of a browsed-out yard by more carefully regulating browsing, but the number of deer-days of browsing which a plot in this condition could withstand was so small that extreme care was needed to prevent further overbrowsing. Since we already have shown that browse deteriorates even with no browsing by deer, this factor alone would add to the problem of estimating sustained carrying capacity after the stand had passed its period of peak productivity.

Although the complexity of the experiments made it necessary to forego some of our secondary objectives, the studies described have demonstrated some very significant trends.

These experiments have shown that the sustained carrying capacity of swamp conifer yards, with cedar and palatable hardwoods predominating, is probably at least two deer to the acre, and may be higher during years of maximum browse production. They have further demonstrated that if the deer population of an area is not permitted to reach a high enough level to browse out the yards, the area will support more deer on a long-range basis. If, on the other hand, the deer herd is allowed to build up to a point where a browse-line is established and plant reproduction is held down by overbrowsing, the original carrying capacity cannot be restored by anything less than a drastic reduction in the herd and by cutting to open up the stand and increase reproduction.

The inability of Plots 9, 10, 11, and 12, containing a high proportion of cedar, to sustain many deer was believed primarily due to the maturity of the stand which has resulted in a great amount of self-pruning and shading out of new reproduction. From a management standpoint it is evident that the only way a higher food potential can be restored in such areas is to cut the older trees so that reproduction of cedar and infiltration of some palatable hardwoods will be encouraged.

The carrying capacity of hardwood yards of the type tested appeared to be much lower than that of conifer yards. Controlled feeding experiments have shown that deer are unable to subsist on a diet of hardwoods alone unless a large quantity and good variety of browse is available, and that a hardwood stand of predominantly hard maple will have a relatively low sustained carrying capacity. From these experiments it was evident that the hardwood type studied would carry probably less than one deer per acre on a sustained basis during its years of maximum production.

The factors of self-pruning, snowshoe hare browsing, and lack of reproduction in an over-age stand are clearly illustrated by the graphs in Figures 1 and 2. It will be noted, with few exceptions, that available browse deteriorated in both the plots that were browsed and in the control plot which was not browsed. The slow rate at which browse in the swamp plots recovered after a five-year absence of deer is shown in Figure 1. Long retirement from browsing did not improve food conditions to the extent that more deer actually could be carried.

An interesting situation developed in the swamp plots as a result of overbrowsing. Although usable cedar browse was decreased by overbrowsing, Nelson (1951) found that the number of stems actually increased, but the increase was greater in the less heavily browsed plots, reaching its maximum in the control plot. The implications in these findings are not clear but the results point up the need for an early determination by the game manager of management objectives in cedar stands, *i.e.*, whether the stand is to be managed primarily for deer or for wood production. The trends in stem increases in several of the swamp plots are shown in Figure 3.

Probably the outstanding finding of these experiments has been that our previous estimates of carrying capacity in heavily browsed

FIG 1

BROWSE AVAILABILITY IN C W E S BROWSE PLOTS

COMPOSITE OF PLOTS 5,6, and 8

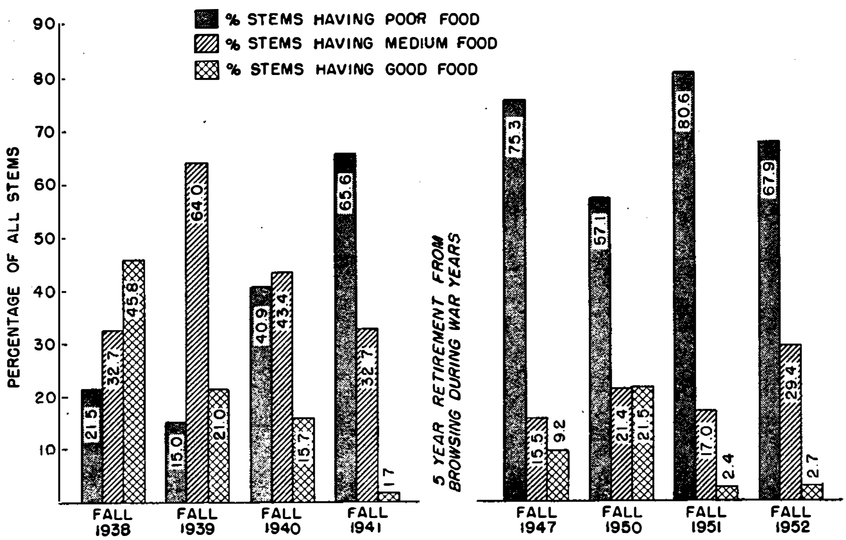
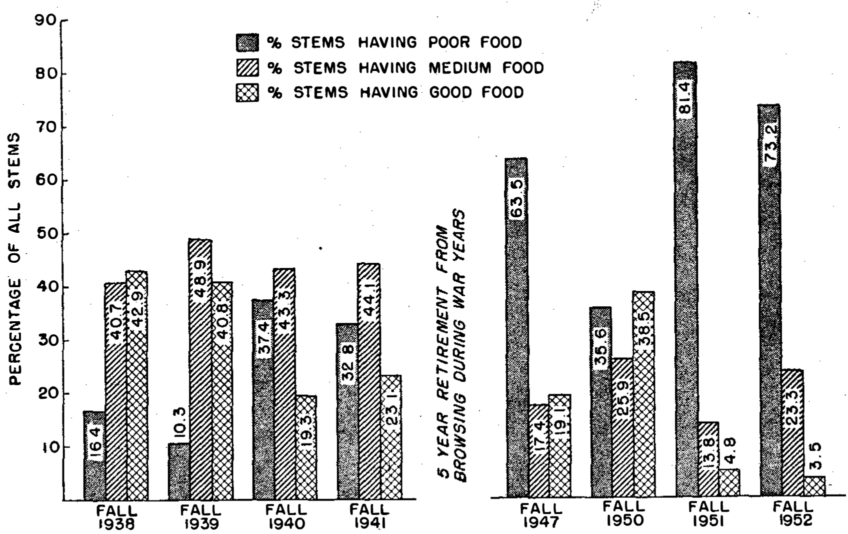


FIG 2

BROWSE AVAILABILITY IN C.W.E.S. BROWSE PLOTS

PLOT 7 - CONTROL PLOT



yards have been low in almost every instance, and that deer populations based on estimated carrying capacity likewise have been low. The fact that such areas will continue to carry up to one deer to the acre year after year has posed an interesting problem for analysis. Although no positive statements can be made at this time to explain the continued relatively high carrying capacity of the plots studied, at least two possibilities have been suggested.

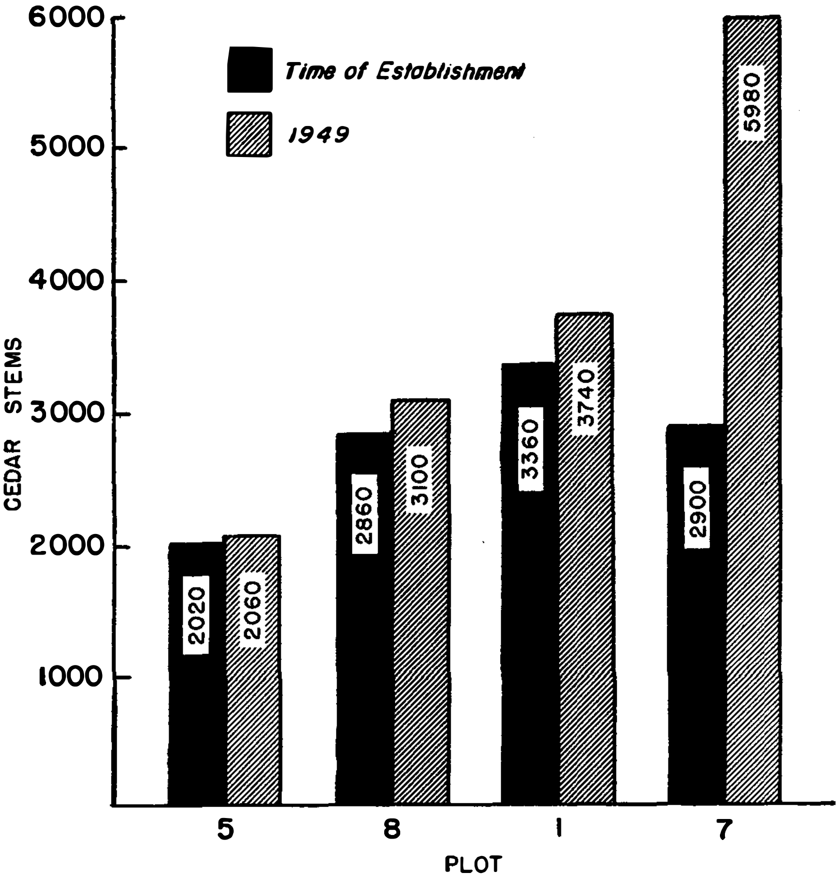
One explanation appears to be in the persistence of several hardwood species, notably black ash (*Fraxinus nigra*), several of the dogwoods (*Cornus*), and nannyberry (*Viburnum lentago*), in surviving and providing a considerable amount of edible browse from annual regrowth in the presence of severe browsing. These and other hardwood species were utilized heavily, and collectively may constitute an important food supply in such overbrowsed swamp stands.

A second factor that may produce a greater amount of available food than could be anticipated on the basis of the fall and spring cruises is the weighting down of the tops of conifers, particularly cedar, by wet snow. This is an extremely difficult factor to measure under present browse evaluation methods, but continued observations have indicated that for short periods many limbs and even tops of smaller trees are placed within reach of deer, and the amount of food produced at such times may be appreciable.

During winters of light snowfall it usually has been assumed that more browse is available because reproduction is not covered by snow.

FIG 3

NUMBER OF CEDAR STEMS OVER TWO FEET IN HEIGHT PER ACRE AT TIME OF PLOT ESTABLISHMENT AND IN 1949



However, the same conditions that bare this additional food supply also may cause the lower limbs of the larger trees to be out of reach, particularly in conifer yards having a high browse line. Such a possibility was suggested last winter when a systematic inspection of a browsed-out yard disclosed an extremely high mortality rate in deer. During that winter, maximum snow depth in the yard was only about one and one-half feet and temperatures averaged considerably higher than normal. Yet on 934 acres, 81 deer, or one to 11.5 acres, were found dead from malnutrition. Of further significance was the fact that approximately 38 per cent of the mortalities were adults. Even under deep snow conditions the browse line was known to be very high, and it seems logical to conclude that this condition, aggravated by a lower than normal snow depth, plus an almost total lack of plant reproduction, may have been the crucial factor causing a high death rate in adults as well as fawns. This observation is cited because it serves to illustrate again the need for more accurate methods of evaluating browse availability and utilization in deeryards at all times of the year and under all weather conditions.

SUMMARY

The need for evaluating (1) amount of available and acceptable browse in northern Michigan deeryards, and (2) sustained carrying capacity of these yards, resulted in experiments at the Cusino Wildlife Experiment Station from 1936 to 1953.

Varying numbers of deer were placed in one-acre plots enclosed by deer-proof fence during the natural yarding season of deer. Carrying capacity of the different plots, representing several types of northern Michigan deeryards, was determined by evaluating browse availability in relation to the condition of the confined deer at the end of each yarding season.

Conclusions were that:

(1) Better types of conifer yards will carry two to three deer to the acre through the yarding season on a sustained basis during years of maximum browse production, but after being browsed out usually will not carry more than one deer to the acre. Hardwood yards in the area studied probably will carry less than one deer to the acre during their time of highest productivity.

(2) Our previous estimates of carrying capacity have been low, and estimated populations of deer in yards based on observed browse conditions also have been low.

(3) A given yard will have the greatest sustained carrying capacity if the number of deer is held to a level compatible with maximum plant reproduction and reasonable utilization of available browse.

From a management standpoint rigid herd control would seem to be necessary in maintaining the desired conditions. Conversely, the control plots demonstrated that unbrowsed yards will deteriorate almost as rapidly through self-pruning and retarded plant reproduction resulting from shading, and from snowshoe hare browsing which also decreases plant reproduction. Good management, therefore, should strive to prevent underutilization as well as overutilization of those yards having high browse production.

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EFFECTS OF BEETLE-KILLED TIMBER ON RANGE AND WILDLIFE IN COLORADO[1]

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About 1935 local outbreaks of the bark-beetle (*Dendroctonus engelmanni* Hopk.) began to show up in the extensive stands of old-age Engelmann spruce in Colorado. These infestations were accelerated by blow-downs of spruce timber in 1939 and, by 1945, an appreciable area of high-altitude forest had been killed by the insects. The epidemic continued to spread during the next five or six years until, in 1951, a total of about 600,000 acres had succumbed to the beetle horde—the largest semi-contiguous acreage of insect-killed timber on record.

In 1950, extensive control measures were initiated on outbreak areas. Chemical treatment of thousands of actively infested trees was continued through the summer of 1952, which, abetted by woodpeckers and parasites, and weather unfavorable to beetle survival during the

[1]The Colorado A & M College, the Colorado Game and Fish Department, the Wildlife Management Institute, and the Fish and Wildlife Service, Department of the Interior, cooperating.

winter of 1950-51, has resulted in a check in the spread of the beetle. Left standing, however, is an estimated 4,300,000,000 board feet of dead spruce timber, principally on the White River, Routt, and Arapahoe National Forests (Bureau of Entomology and Plant Quarantine, Forest Insect Laboratory, Fort Collins, Colorado, administrative report).

In 1948 it was clearly evident that death of vast tracts of spruce would affect profoundly the floral ecology, and subsequently the fauna, of the areas involved. Such effects would be particularly important on the summer range of deer,[2] elk, and livestock; and of at least general importance to a large number of birds and smaller mammals resident wholly or in part in the spruce-fir type. In view of these obvious relationships, it was the consensus of the Colorado Game and Fish Department, Forest Service, National Park Service, Colorado A & M College, and Unit personnel that beetle-affected areas should be studied from the range and wildlife standpoints.

In 1949 the Colorado Cooperative Wildlife Research Unit began a formal investigation of these problems, wherein the changes developing in dead timber were compared with the same factors in green, uninfested stands. In 1950 the study was enlarged through participation of the junior author, addition of sample plots in both green and dead spruce, and initiation of standard range appraisal studies. The results for the first four years of study are presented in this paper.

METHODS

Statisticians recognize the difficulty of sampling large areas, especially when specific data on numerous forms and conditions are desired. The sampling problem is further complicated when time and manpower for field work are limited.

Under these conditions it was necessary to adopt procedures in this investigation that would give information suitable for administrative needs. In the present instance, such information was desired on the effects of timber death on both range and wildlife. It was recognized that the methods dictated by circumstances would yield little, if any, information on fish, beavers, minks, and muskrats; and perhaps only general impressions on big game and terrestrial fur animals.

In order that check data be provided, it was concluded that similar studies should be made simultaneously in beetle-killed and green, uninfested stands. In September, 1949, 25 permanent study plots were established in dead and dying spruce stands around Trappers Lake, Garfield County, and 25 in green spruce in the vicinity of Cameron

[2]For scientific names of animals considered in this paper, see Tables 7 and 8. Exceptions are given in the text.

Pass, Jackson County. In 1950, these samples were doubled by the addition of 25 plots in dead timber around Stillwater Reservoir, Garfield County, and 25 in green timber in Gunnison County (Table 1).

Plot establishment did not follow a random pattern, which would have resulted in plots in willow thickets, aspen groves, meadow, and even open water. Since only the spruce-fir type, and its inclusion of lodgepole pine, was being considered, it was thought permissible to depart from strict random practice. Accordingly, plots were located so as to fall into typical spruce-fir stands; they were roughly a quarter-mile apart and generally oriented so as to ascend mountain slopes, beginning at stream, lake, or meadow edge. This procedure resulted in a sample variable as to slope, exposure, and stand elevation, thus including more site factors in the sample. It is believed that a general representation was obtained for stands in which work was done. All plots were established, and subsequently checked each year, in September.

Sample plots were quarter-acre circles about 60 feet in radius, the distance from center to circumference being fixed by the use of a thin rope of this length. A prominent spruce or fir, on or near the compass line, was selected as the center tree, to which a 6-inch square sheet of aluminum was nailed, head high, with galvanized nails. On this marker the date, transect number, and plot number were scratched with a sharpened nail. The various data recorded at the time of plot establishment are indicated in Figure 1.

Range evaluation on both dead- and green-timber plots was accomplished by a combination of two methods, the ocular appraisal (Inter-Agency Range Survey Committee, 1937), and the line-intercept method (Canfield, 1942), adapted to conditions encountered. The ocular appraisal gave total ground-cover density, excluding trees, in per cent, and permitted an estimate of relative abundance by species for each plot and each study area.

Line transects were oriented at right angles to the direction of travel in establishing plots; each began at the base of the plot tree, at a point marked by a two-inch staple driven into the root collar, and terminated 25 feet distant. Terminal points were also marked permanently by stakes. A small metal cable, one-eighth-inch thick, was used as a transect guide, on which the exact 25-foot point was marked by a small copper tab. In practice, the cable was snapped to the staple, stretched tightly over the pointed center of the stake, and fastened securely with an iron rod driven into the ground. Ideally, the cable lay on, or within an inch or two of, the ground, but logs sometimes forced it a foot or more above ground. In such cases, plants

TABLE 1. DATES OF ESTABLISHMENT, LOCATION, STAND AND SITE CONDITION, AND BEETLE HISTORY OF SPRUCE-FIR SAMPLE PLOTS, COLORADO

	Green Timber			Beetle-killed Timber			Beetle History		
Date	Location	No. of Plots	Stand and Site Condition	Location	No. of Plots	Stand and Site Condition	Initial Infestation	Epidemic	Timber killed
1949	Lake Agnes	25	Overmature; moist; pure spruce-fir	Trappers Lake	25	Mature; moist; spruce-fir and lodgepole pine	1939	1946	1947-50[1]
1950	Gunnison County	25	Mature; dry; pure spruce-fir	Stillwater Reservoir	25	Mature; moist to dry; pure spruce-fir with lodgepole pine on dry sites	1940	1945	1947-48

[1]Delay in death due to lodgepole in composition, which was killed by beetles from one to two years after death of spruce.

COLORADO WILDLIFE RESEARCH UNIT and COLORADO GAME AND FISH DEPARTMENT
Fort Collins, Colorado Denver, Colorado

Date 9 - 3 - 50 Series DEAD

RANGE AND FAUNAL SURVEY, SPRUCE-FIR TYPE

Transect No. II Plot No. 5 Elevation 10,260′ Bearing DUE SOUTH OF PLOT 4
Location: T 1N R 87W PM 6 TH Watershed YAMPA RIVER Locality STILLWATER RES.
Description of transect starting point SPRUCE TREE, 22″ DBH, ON TRAIL ALONG SOUTH SHORE OF RESERVOIR; ABOUT 150 YDS. WEST OF SW END OF DAM.

Forest Stand: DBH: 8-18″ SITE CLASS II

Species	No. Trees on Plot: Living	Dying	Dead	Remarks
Spruce	0	|||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |||	STAND DEAD 2-3 YRS.
Fir	𝍸 𝍸 𝍸 𝍸 𝍸 ||	||	𝍸 ||	
Lodgepole pine	0	0	0	

Reproduction (3″ DBH and less) LARGELY FIR, 1-2″, STUNTED, BUT ENOUGH TO GIVE OPEN TO CLOSED STANDS.

Range

Understory: (Grasses, forbs, browse) Density, per cent 45 Degree of Use LIGHT

Species			Species	
1.	VACCINIUM	10	6. PEDICULARIS	2
2.	SENECIO	2	7. DELPHINIUM	2
3.	ARNICA	4	8. LONICERA	T
4.	ASTER	2	9. RIBES (SEEDLINGS)	T
5.	GRASSES (MAINLY BROMUS)	4	10. SAMBUCUS (SEEDLINGS)	T

Class of Animal: Cattle ✓ Sheep ___ Deer ✓ Elk ? Other ___

Fauna

Weather at Time of Observation CLEAR, WARM (60° F) BREEZE Time 1:37 PM

Species Seen	No.
Pine squirrel	2
Ground squirrel	
Chipmunk	1
Snowshoe rabbit	
Marmot	
Cony	
Jay	
Woodpecker	2
Blue grouse	
Pine grosbeak	1
Small birds	6-7

Squirrel cuttings (fresh only): ✓
Tracks: DEER
Droppings: SNOWSHOE RABBIT
DEER
Miscellaneous: PORCUPINE DAMAGE TO 1 GREEN SPRUCE, 3″ DIAM.
• LARKSPUR HEADS CROPPED BY DEER

Remarks GROUND COVER HEAVY, VACCINIUM, MIXED WEEDS & GRASSES. MUCH DOWN TIMBER — SOME FOR SEVERAL YEARS.

YEAGER AND RIORDAN Observer

Figure 1.—Form used in recording field data.

under the line were included or excluded by the use of a small plumb-bob.

In the initial as well as in successive measurements all vegetation on the transect was recorded by genera, and by species for dominant forms. The diameter of each stem and clump involved was measured just above the ground with an engineer's scale graduated in inches and tenths. The data so obtained could, of course, be expressed as frequency of occurrence by species, and in per cent for each plant genera or species, giving an actual, measured, quantitative density expression.

Information for diurnal forms was obtained largely from 15-minute time-interval counts at each plot, made at the time of establishment and at each subsequent annual check, and recorded under *Fauna* on the field form (Fig. 1). These counts were always taken immediately after the quietest approach possible to or very near to the center tree; and at the time of plot establishment, before nailing on markers or taking other data in the vicinity.

For big game, much of the information was obtained from feeding, track, and scat signs, noted while covering plots for this purpose or while making forage measurements.

Nocturnal animals, limited to mice and shrews, were sampled with conventional museum-special traps. The samples obtained were small, but they were taken in approximately the same manner and from the same area each year, giving them a high degree of comparability. A continuous line of 100 traps, rather than the "standard" line proposed by Calhoun (1949), was employed. Traps were placed five steps apart, each line therefore being about 500 yards long. The lines were operated for three consecutive nights, and in all cases they ran from timber edge to the interior of the stand, such orientation generally being uphill and at right angles to the slope.

ECOLOGICAL ROLE OF THE SPRUCE-FIR TYPE

In Colorado there is an estimated 14,950 square miles (14.4 per cent of the state) in summer range (Yeager, Denney, and Hammit, 1949 :8), of which the spruce-fir (*Picea engelmanni-Abies lasiocarpa*) type constitutes about 50 per cent by area. Alpine meadow, bordering and intermixed with the spruce, and generally at higher elevations, is the most important summer-range forage type. Lodgepole pine and aspen stands, again bordering and intermixed with spruce-fir, but at lower elevations, provide variable cover, and similar utility to wildlife, as delineated by slope, exposure, moisture, and soil type. The forage value of aspen may be high, especially to deer. Relatively little forage is found in mature spruce stands.

Spruce-fir, between elevations of 10,000 and 11,500 feet, is the climax forest type in Colorado. In the normal green state, these forests dominate all other vegetation within their influence, utilizing a very large portion of the available light, moisture, and soil nutrients. The spruce, at least, is long-lived and slow-growing, producing one-story stands which, once established, remain relatively static for long periods of time, certainly 100 to 200 years or more.

These ecological conditions result in open forests, more or less brushless on dry slopes and with varying densities of undergrowth on moist sites. In all spruce-fir stands, such features as small streams, rock outcrops, draws, windfalls, and standing dead trees and snags give some relief to the otherwise monotonous continuity of unbroken forest cover. Stands are bisected by the headwater stretches of the streams, which are seldom more than a few feet wide, and which are often hidden by a dense, generally scrubby, growth of willow (*Salix* spp.). Beavers build a succession of dams along many such streams, resulting in alternate impoundments and brush-meadow areas. These variations in cover and terrain, interspersed with aspen fringes and innumerable alpine meadows, add immeasurably to the attractiveness of spruce-fir forests to big game and probably to most indigenous birds and mammals.

In green spruce timber, the predominating ground cover is billberry (*Vaccinium* spp.), which often carpets the forested area. On dry sites there may be, in addition, a shrubby buffaloberry (*Lepargyroea*) and scattered composites, especially *Arnica* and *Aster*. On moist sites appreciable forb and shrub growth may occur. The most common weeds are mountain bluebells (*Mertensia*), larkspur (*Delphinium*), butterweed (*Senecio*), and various asters. Moist-site shrubs are mainly wild currants (*Ribes* spp.), elderberry (*Sambucus* spp.), and willow.

The summer range thus described is grazed generally by livestock, although sheep and cattle are usually allocated to different areas. In Colorado, deer and elk find summer range throughout the spruce-fir type and on the alpine meadows adjoining and above. Late fall and late spring range for big game is generally below the spruce-fir type, beginning with lodgepole pine and aspen, and extending down to winter range proper.

In addition to its value as summer range, the spruce-fir type in Colorado is the typical habitat of several species of small game, and of a large number of fur animals and non-game forms. Included are the blue grouse (*Dendragapus obscurus*), snowshoe rabbit, marten (*Martes caurina*), mountain red fox (*Vulpes macroura*), weasel (*Mus-*

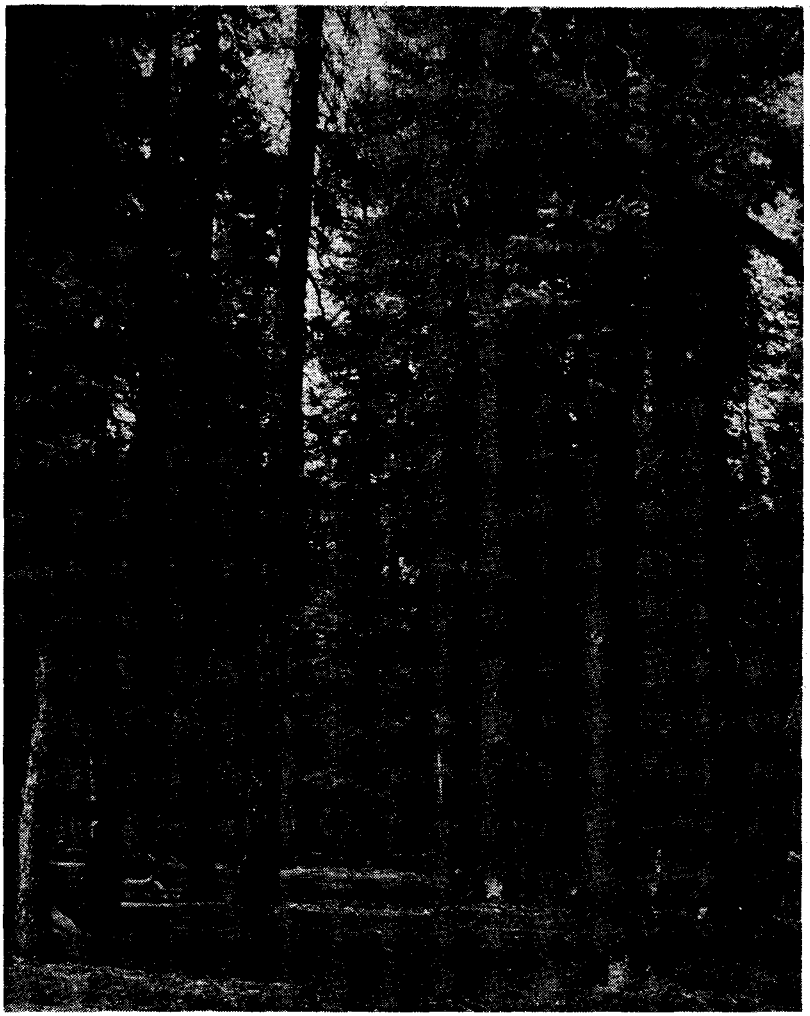

Figure 2.—Typical green spruce-fir stand on dry site near Los Pinos Pass, Colorado, September 1952. Note almost complete absence of grass, forbs, and shrubs.

tela frenata), lynx (*Lynx canadensis*), pine squirrel, and many small mammals and birds.

The faunistic role of high-country forests can be more fully appreciated when these relationships are better understood. For elk, the spruce-fir and associated coniferous and aspen types hold many grasses, forbs, and shrubs eaten in late spring, summer, and early fall (Murie, 1951:199-222; Young and Robinette, 1939:23-39; Ratcliff, 1941:133). For mule deer, a similar food relationship has been indicated by Russell (1932:8-9); Warren (1942:282); Rasmussen (1939: 243); Rateliff, (1941:133). These coniferous forests, with the bordering and intermixed types, are important calving and fawning range for elk and deer (Murie, 1941:133; Cahalane, 1947:36; Warren, 1942: 278). Both species make use of the spruce-fir complex during summer storms and during the warmer hours of summer days (Murie, 1941: 263; Russell, 1932:7; Dixon, 1934:56). Finally, it is largely in spruce stands (in Colorado) that elk, and often mule deer, seek and find protection from hunters, without which kills of the elk especially would be greater than they are.

For small game, certain fur animals, and the host of small mammals and birds indigenous to high-altitude forests in Colorado, the spruce-fir type represents the basic range, and for many such forms it is the year-around habitat. Both the snowshoe hare and the blue grouse occur in greatest numbers in this cover, although both occur below spruce-fir and in other types. In Colorado, the heaviest concentrations of hares are found when spruce-fir forest merges into willow and alder swales; the Rocky Mountain cottontail (*Sylvilagus nuttallii*) may occur to 11,000 feet, but no appreciable number is found above lodgepole pine (Warren, 1942:259, 271; Yeager, unpublished). Grouse are most abundant in thin spruce-fir and Douglas-fir stands undergrown by or adjacent to hardwood brush. Ptarmigan occur almost entirely above the spruce forests, although they frequent the timberline edges of this type.

Of fur animals, the marten, the red fox, and both the long-tailed and mountain weasels are closely associated with spruce-fir, and occur, of course, in other types. Of these three, weasels are regarded as relatively non-migratory; martens and foxes apparently make some adjustment in altitude with the seasons. The lynx, very scarce if present at all in Colorado, is confined to the most remote spruce-fir stands; and the fisher (*Martes pennanti*) and the wolverine (*Gulo luscus*), usually associated with wilderness forests (mainly Canadian and Hudsonian Zones), probably do not occur in the state.

Among small mammals, the most conspicuous and one of the most common is the pine squirrel, found in all coniferous stands above the Transition (6,000-8,000 feet) zone. It reaches a density of two animals to the acre in some mature spruce-fir stands in Colorado (Yeager, unpublished), the highest density so far observed in the state. Mice of the genera *Peromyscus, Microtus, Phenocomys,* and *Clethrionomys,* may be common to abundant; shrews are more or less common on moist, well-forested areas. Chipmunks typically occur in small parks and grass and weed openings throughout the spruce-fir zone. Pikas or conys, residents of rockslide areas, occur both in the stands and at and above timberline.

Non-game birds associated with these high-mountain forests are numerous. Among permanent residents are Canada jays, pine grosbeaks, chickadees (*Penthestes* spp.), redbreasted nuthatch (*Sitta canadensis*), creeper (*Certhia familiaris*), raven (*Corvus corex*), horned owl (*Bubo virginianus*), goshawk (*Astur atricapillus*), and at least three woodpeckers, hairy (*Dryobates villosus*), downy (*D. pubescens*), and three-toed (*Picoides tridactylus*). The red-shafted flicker (*Coloptes cafer*) was observed near timberline in September. Clark's nutcracker (*Nucifraga columbinana*) is sometimes a year-around resident. A wide variety of small perching birds migrate through the stands during the spring and fall.

In summary, it can be said that in Colorado the spruce-fir type, in its green state, is the basic habitat of many valuable game, fur, and non-game animals, several of which are comparatively rare. Any major catastrophe, such as loss of timber on a vast area, is regarded as certain to be of significance from the range and wildlife standpoints.

RANGE TRENDS

Reliable determination of range trends was complicated by certain differences in the Los Pinos site. While there was general comparability in all areas as to slope, exposure, and elevation, the Los Pinos sample was about 150 miles farther south. It also differed in fire history and, more significantly in soil characteristics; it was more porous and, therefore, drier than the other three sites, the results of which are reflected in range-plant density, Table 2. Evidence of fire, which occurred at least 300 years ago, is still to be seen in the form of charred stumps, and the long-fallen, nearly disintegrated, aspen succession which followed. A nearly pure spruce stand, with trees up to two feet in diameter and up to 300 years old, now occurs on the Los Pinos

TABLE 2. DENSITY COMPARISON OF RANGE PLANTS BY RECONNAISSANCE METHOD, EXPRESSED IN PER CENT, GREEN *VS*. DEAD SPRUCE-FIR, COLORADO, 1950-1952[1]

	Green Spruce-fir		Dead Spruce-fir	
Year	Lake Agnes	Los Pinos	Trappers Lake	Stillwater Reservoir
1950	33.0	3.7	21.0	26.6
1951	31.7	3.0	27.5	33.6
1952	29.8	6.4	28.0	36.4

[1]See Table 1 for description of sites.

area, giving it close comparability in this respect to the other three tracts.

In addition to differences in site, unfortunate from the standpoint of interpretation but compensating in that they brought a wider range of the spruce-fir type into study, the elapsed period of only three years (of range studies) precludes other than general indications in forage trends. These, as determined through 1952, are given in Tables 2 to 5 inclusive.

Regardless of site differences, it is rather clear from data given in Table 2 that forage density, as determined by the reconnaissance method, remained nearly static or retrogressed slightly in green spruce-fir, and increased more or less steadily in the dead stands. The one deviation from this trend, the increase in density on the Los Pinos area in 1952, may be explained by the relatively wet growing season that year on the small amount of ground cover present; in both volume and coverage it still remained very small, despite the more than 100 per cent increase.

It is of interest to note that ground-cover density in the Lake Agnes stand was greater, in 1950, than in either of the dead stands. This difference is believed attributable mainly to soil moisture, noticeably greater at Lake Agnes than either Trappers Lake or Stillwater Reservoir. Despite the greater original ground-cover density at Lake Agnes, it is considered significant that the trend here is downward and that the 1950 density was surpassed at Stillwater in 1951 and closely approached at Trappers Lake in 1952.

In dead stands there is no doubt of the steadily upward density trend. It should be recognized, however, that these figures were arrived at by the reconnaissance method and that they are concerned mainly with perennial rather than annual plants. The increase in density should, therefore, be regarded as the result of increased vigor in residual plants subsequent to release, as well as to the appearance of seedlings in increasing numbers.

In Table 3, where the data were obtained by precise measurement, a less simplified, and probably more accurate, indication of vegetative change is shown. Here, grasses and sedges show progressive retrogression in green timber, and variable but generally increased density in dead timber.

Forbs, in both green and dead spruce, showed some fluctuations by years in intercept density but maintained relatively static positions. However, about 2.3 times more forbs were encountered in dead than in green timber. Browse, on the other hand, showed steady and nearly parallel retrogression in both timber types. This surprising be-

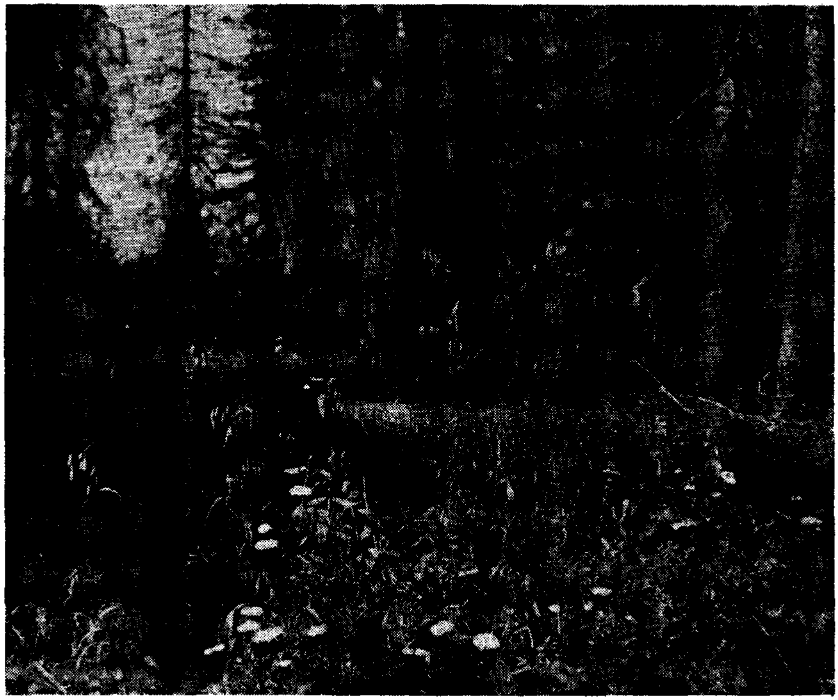

Figure 3.—Grasses and forbs respond to release, or become established through invasion, in spruce-fir timber killed by bark-beetles. Nodding brome, asters, and many other grasses and forbs are represented in the developing ground-cover complex.

havior cannot be explained by the writers at this time, except for the possibility of a leaf-spot disease detected late in 1952. Since *Vaccinium* represented 90 per cent of all browse at Lake Agnes, and 86 per cent of all browse at Trappers Lake and Stillwater Reservoir, it is obvious that the performance of other woody species was masked, and that parallel decimation in all stands made it difficult to measure the role

TABLE 3. FORAGE TREND, BASED ON LINE-INTERCEPT MEASUREMENTS, EXPRESSED IN INCHES, GREEN *VS.* DEAD SPRUCE-FIR, COLORADO, 1950-1952[1]

	Green Spruce-fir				Dead Spruce-fir			
Forage Group	1950	1951	1952	Total	1950	1951	1952	Total
Grasses, Sedges ..	13.1	8.7	8.1	29.9	17.7	13.2	22.9	53.2
Forbs	22.5	43.1	31.2	96.8	77.1	83.7	68.5	229.2
Browse	100.2	76.3	44.2	220.7	104.0	66.5	46.5	216.9
Totals	135.8	128.1	83.5	347.4	199.2	163.4	137.9	499.3

[1]Green spruce-fir figures involve Lake Agnes data only, while those for dead spruce-fir are the *average* of Trappers Lake and Stillwater Reservoir Data. This treatment permitted comparison of generally comparable sites.

TABLE 4. BROWSE TREND, BASED ON LINE-INTERCEPT MEASUREMENTS, EXPRESSED IN INCHES, GREEN *VS.* DEAD SPRUCE-FIR, COLORADO, 1950-1952[1]

	Green Spruce-fir				Dead Spruce-fir			
Browse	1950	1951	1952	Total	1950	1951	1952	Total
Vaccinium	96.4	63.1	39.2	198.7	103.9	66.5	46.5	216.9
All other browse	3.8	13.2	5.0	22.0	8.7	9.8	11.2	29.7
Totals	100.2	76.3	44.2	220.7	112.6	76.3	57.7	246.6

[1]Green spruce-fir figures involve Lake Agnes data only, while those for dead spruce-fir are the *average* of Trappers Lake and Stillwater Reservoir data. This treatment permitted comparison of generally comparable sites.

of timber death on woody forage. A comparison of *Vaccinium* with other browse is shown in Table 4.

The small gains shown in browse other than *Vaccinium,* in both green and dead stands, were due mainly to the growth of *Abies* reproduction after release, and to a small increase in the number of *Ribes, Pachystima, Lonicera* and other shrubs.

It was not surprising that a large number of plants, both species and individuals, were encountered in this investigation. There was a significant difference in number, as well as occurrence, of species in the two stand conditions, the greater number and density being found in dead timber. This site-species relationship is summarized in Table 5.

TABLE 5. NUMBER OF PLANT SPECIES BY AREAS AND YEARS, GREEN *VS.* DEAD SPRUCE-FIR, COLORADO, 1950-1952[1]

	Number of Species			Number of Occurrences, all Species, 25 Plots					
				Number			Index of Abundance[2]		
Area	1950	1951	1952	1950	1951	1952	1950	1951	1952
Lake Agnes	20	20	18	95	103	102	3.80	4.12	4.08
Los Pinos	17	16	17	44	44	39	1.76	1.76	1.53
Trappers Lake ..	35	37	35	124	145	129	4.96	5.80	5.16
Stillwater Res. ..	34	32	35	127	126	133	5.08	5.04	5.32

[1]Exclusive of trees over 3 inches in diameter, mosses, and lichens.
[2]Calculated by dividing number of occurrences by 25.

In terms of abundance, it was evident from three different tests—ocular reconnaissance, intercept measurements, and the number and occurrence of species—that the greatest amount of forage was found in beetle-killed timber. Abundance in the two green-timber types was governed by the amount of soil moisture and, for this reason, showed wide divergence in growth and density. It is significant, however, that the greatest density, the greatest number of species, and the highest index of species occurrence, was in the dead stands.

WILDLIFE TRENDS

The limitations imposed on faunistic comparisons between dead and green spruce-fir, due to lack of time and man power and inability to sample population trends under winter conditions, have been indicated. The following is a comparison of trends for certain diurnal forms and for small, mainly nocturnal, rodents—a continuation of the investigation begun in 1949 (Yeager, 1950). The basis on which these trends were determined, and the size of the samples employed, are summarized in Table 6.

A gross comparison of diurnal animals, as determined in 174 time-interval observations in green spruce-fir and 175 in dead spruce-fir, is presented in Table 7. From these results, it is evident that death of the spruce had a variable effect on the birds and mammals concerned. For pine squirrels and pine grosbeaks, it was detrimental; for chipmunks, woodpeckers, and perhaps pikas, it was beneficial; and for all other forms considered here, it was uncertain. On the basis of numbers recorded, it would appear that small birds were adversely affected, but the data in this instance are severely discounted due to the difficulty of enumerating highly mobile forms in dense forest canopy over a 15-minute period.

For all forms clearly affected by timber death, it is believed that food was the principal determining factor. Thus, the nearly complete loss of spruce seed, and the pronounced increase in grasses, forbs, and shrubs, was reflected, respectively, in the striking decline of pine squirrels and increase in chipmunks. The pine grosbeak showed a similar response to decreased food. Pikas were observed in numbers too small to be significant, but their reaction to increased forage appeared to be positive. Woodpeckers showed a highly significant response to great quantities of food in the form of spruce-beetle larvae, but declined precipitately, or migrated, as this supply was exhausted in dead timber. The data for snowshoe rabbits are not conclusive, but the indications are that, to date, timber death has imposed no severe environmental hardship. The ubiquitous Canada jay was little affected by the beetle epidemic and subsequent death of timber stands.

The effect of stand death on mice and shrews, and further evidence of its effects on chipmunks, are given in Table 8. Paralleling the findings disclosed in time-interval observations, trapping results indicated the pronounced increase of chipmunks in dead timber. The percenttage of increase as determined by the two methods of sampling was, approximately, 221 in time-interval data (Table 7), and 225 in trapping data (Table 8), a circumstance giving validity to the results. Increased food supplies in the form of grass, weed, and shrub seed, together with development of more favorable cover inherent in herbaceous succession, are presumably the reasons for chipmunk increase.

Meadow mice showed a similar rise in populations, for which the

TABLE 6. SUMMARY OF TIME-INTERVAL OBSERVATIONS AND TRAP-NIGHTS BY STAND CONDITION, AREA, AND YEAR, COLORADO

	Green Spruce-fir					Dead Spruce-fir			
Area	1949	1950	1951	1952	Area	1949	1950	1951	1952
I. Numer of 15-minute Time-interval Observations									
Lake Agnes	25	25	25	24[1]	Trappers Lake	25	25	25	25
Los Pinos	....	25	25	25	Stillwater Reservoir	....	25	25	25
Total 174					Total 175				
II. Number of Trap-nights									
Lake Agnes	200	150	300	300	Trappers Lake	250	135	300	300
Los Pinos	....	360	300	300	Stillwater Reservoir	....	360	300	300
Total 1,910					Total 1,945				

[1]One plot recently logged, 1952.

TABLE 7.—TIME - INTERVAL OBSERVATIONS, GREEN *VS.* DEAD SPRUCE-FIR, COLORADO, 1949 - 1952

Animals and Observations	Green Spruce-fir: 174 15-minute Observations		Dead Spruce-fir: 175 15-minute Observations	
	Total Seen	Seen Per 15-minute Period	Total Seen	Seen Per 15-minute Period
Pine squirrel, *Tamiasciurus fremonti*	369	2.12	133	0.76
Chipmunk, *Eutamias minimus*	29	0.17	93	0.53
Snowshoe hare, *Lepus americanus*	3	0.02	4	0.02
Pika, *Ochotona princeps*	5	0.03	19	0.11
Canada jay, *Perisoreus canadensis*	119	0.68	122	0.70
Woodpeckers, *Picoides*, *Dryobates*	33	0.19	118	0.67
Pine grosbeak, *Pinicola enucleator*	174	1.00	85	0.49
	732	4.21	574	3.28
Small birds: *Penthestes*, *Sitta*, *Certhis*, *Regulus*, *Junco*, *Turdus*, etc.	658	3.78	498	2.85
Sign (fresh only):				
Pine squirrel cuttings	119	0.68	57	0.33
Tracks:				
Deer, *Odocoileus hemionus*	92	0.53	115	0.66
Elk, *Cervus canadensis*	27	0.16	29	0.17
Droppings:				
Deer, *O. hemionus*	41	0.24	51	0.29
Elk, *C. canadensis*	22	0.13	26	0.15
Snowshoe hare, *L. americanus*	128	0.74	118	0.67
Porcupine, *Erethizon epixanthum*	14	0.08	7	0.04

same reasons are believed to hold. Similar, but less conclusive, are the data for lemming mice and, perhaps, for shrews. In the case of shrews, it is felt that a denser, and therefore more moist, ground cover, with more fallen trees and debris, gave rise to the greater number observed in dead timber. Obviously, the findings are too limited for conclusions.

On the basis of gross numbers (Table 8), neither white-footed mice nor red-backed mice were affected profoundly by the changes in stand conditions. This indication is strengthened by information given in Table 9, which shows for 1949-1950 to 1952, inclusive, a downward trend in white-footed mice in both green and dead timber, and an

TABLE 8.—SNAP-TRAP RESULTS, GREEN *VS.* DEAD SPRUCE-FIR, COLORADO, 1949-1952

Species or Genera	Green Spruce-fir, 1,910 Trap-nights		Dead Spruce-fir, 1,910 Trap-nights	
	Total Catch	Catch per 100 Trap-nights	Total Catch	Catch per 100 Trap-nights
Chipmunk, *Eutamias minimus*	12	0.63	39	2.01
White-footed mouse, *Peromyscus maniculatus*	38	1.99	43	2.21
Red-backed mouse, *Clethrionomys gapperi*	71	3.72	62	3.19
Meadow mouse, *Microtus montanus*	4	0.21	46	2.37
Lemming mouse, *Phenacomys intermedius*	6	0.31	15	0.77
Shrews, *Sorex* spp.	12	0.63	24	1.23
Jumping mouse, *Zapus princeps*	1	0.05	2	0.10
Totals and Averages	144	7.54	231	11.88

TABLE 9.—TREND IN SMALL BIRD AND MAMMAL POPULATIONS, GREEN *VS.* DEAD SPRUCE-FIR, 1949-1952[1]

	Green Spruce-fir				Dead Spruce-fir			
	1949 -1950[2]		1952		1949 - 1950		1952	
Animals and Size of Sample	Total Seen	Seen per 15-minute Period	Total Seen	Seen per 15-minute Period	Total Seen	Seen per 15-minute Period	Total Seen	Seen per 15-minute Period
I. Small Birds and Mammals: Mainly Diurnal, Time-interval Sampled								
No. 15-minute Counts	50		49		50		50	
Pine squirrel	100	2.00	127	2.59	54	1.08	28	0.56
Chipmunk	9	0.18	9	0.18	15	0.30	39	0.78
Snowshoe rabbit	1	0.02	0	0.00	2	0.04	0	0.00
Pika	2	0.04	2	0.04	5	0.10	10	0.20
Canada jay	41	0.82	21	0.43	41	0.82	40	0.80
Woodpeckers	15	0.30	4	0.08	78	1.56	4	0.08
Pine grosbeak	16	0.32	21	0.43	19	0.38	37	0.74
Small birds	151	3.02	186	3.79	131	2.62	165	3.30
Animals and Size of Sample	Total Caught	Catch per 100 Trap-nights	Total Caught	Catch per 100 Trap-nights	Total Caught	Catch per 100 Trap-nights	Total Caught	Catch per 100 Trap-nights
II. Small Mammals: Mainly Nocturnal, Snap-trap Sampled								
No. Trap-nights	560		600		610		600	
Chipmunk	6	1.07	0	0.00	9	1.48	15	2.50
White-footed mouse	20	3.57	7	1.17	24	3.93	7	1.17
Red-backed mouse	11	1.96	40	6.67	22	3.61	35	5.83
Meadow mouse	1	0.18	0	0.00	1	0.17	33	5.50
Lemming mouse	0	0.00	5	0.83	0	0.00	15	2.50
Shrews	10	1.79	0	0.00	18	2.95	1	0.17

[1]See Tables 7 and 8 for scientific names.
[2]Initial observations began in 1949 for Lake Agnes and Trappers Lake; in 1950 for Los Pinos and Stillwater Reservoir. These four initial counts are combined for purposes of this table, giving the beginning date of 1949-1950.

upward trend in red-backed mice in both stand types. For each group the trend suggests cyclic behavior more than the effect of environmental disturbance, although the four-year study period is too short to permit conclusions. Lemming mice likewise showed increased numbers in both green and dead timber, but the greatest number in beetle-killed stands. Shrew populations were definitely down in each type but, like lemming mice, the greatest density was encountered in dead timber.

SUMMARY

1. The spruce barkbeetle (*Dendroctonus engelmanni* Hopk.) has killed approximately 600,000 acres of Engelmann spruce timber in Colorado since about 1939. The epidemic attained a peak in 1947-1950, and has been stabilized since by weather and biological and chemical controls.

2. It was the consensus of land-management personnel in Colorado that timber death on this scale would affect big game and livestock on the summer range, and be of environmental importance to many birds and smaller mammals indigenous to the spruce-fir type.

3. A formal study of some of the ecological effects of the beetle infestation was begun by the Colorado Cooperative Wildlife Research Unit in September, 1949, and augmented one year later by the addition of other personnel, range studies, and sample plots. This paper reports findings for the first four years.

4. Sampling was complicated by the large area affected by the beetles, and by limited time and manpower. Fifty quarter-acre study plots were established in 1949 and 50 in 1950, one-half of which, each year, were placed in green spruce-fir and one-half in dead spruce-fir. Plot descriptions, vegetative and terrestrial characteristics, and range and faunistic data, were recorded at time of establishment, and repeated each September subsequently.

5. Ground cover changes were determined annually by three criteria: ocular reconnaissance, line-intercept measurements, and the number and occurrence of species. The resulting data indicated plant abundance by species, total density, species composition and occurrence, and the general trend in forage retrogression or invasion.

6. Faunal studies were limited to certain diurnal forms and to nocturnal groups such as mice and shrews. Only limited information was obtained for big game and terrestrial fur animals, and none for aquatic forms such as fish, muskrats, and beavers. Trends in diurnal populations were determined on the basis of 174 time-interval observations in green spruce-fir, and 175 in dead spruce-fir. Information for mice and

shrews was obtained by snap-trap sampling, totaling 1,910 trap-nights in green timber and 1,945 in dead timber.

7. In Colorado, there is an estimated 14,950 square miles in summer range, of which the spruce-fir type constitutes about one half. These high-elevation forests, in their green state, are the basic habitat of many common and valuable game, fur, and non-game animals.

8. Spruce-fir, the climax forest type in Colorado between 10,000 and 11,500 feet elevation, is slow-growing, relatively static, and of one-story structure; it utilizes a very large portion of the available light, moisture, and soil nutrients.

9. Ground cover, in green spruce-fir stands, is often sparse, consisting mainly of *Vaccinium* and shade-tolerant forbs. A wider variety of forbs, and more browse and grass, were encountered in dead than in green stands. The number of ground-cover species varied from 16 to 20 in green timber, and from 32 to 37 in dead timber.

10. Ground cover varied widely in density in green stands (3 to 33 per cent), but showed consistently high density (21.0 to 36.4 per cent) in dead timber. The density trend was static or downward in green stands, and steadily upward in dead stands.

11. In line-intercept measurements, where stem diameter was used as the criterion of density, an over-all decline was noted in both stand conditions, but was more pronounced in green timber.

12. It was evident from each of the three tests used that the greatest amount of ground cover occurred in dead spruce. During 1950-1952, grasses and sedges showed nearly twice the density in dead as compared to green stands; forbs were about 2.3 times more abundant in dead than in green spruce; and browse, about 90 per cent of which was *Vaccinium,* showed nearly the same abundance in both timber types.

13. Vaccinium showed a progressive and parallel decline in density in both green and dead forests, the decrease being about 59 per cent in uninfected, and about 55 per cent in beetle-killed timber. The reason for this similarity in results cannot be clearly explained by the writers.

14. Death of spruce forests, in terms of increased forage on the summer range, was advantageous to deer and elk, although it must be recognized that little or no shortage in summer range now exists.

15. Stand death was detrimental to pine squirrels and pine grosbeaks, presumably due to loss of food represented by spruce seed; it was advantageous to chipmunks, woodpeckers, and perhaps pikas, due to increased food supplies; and unimportant or uncertain to snowshoe rabbits, Canada jays, small birds, and other diurnal species encoun-

tered. Woodpecker abundance in dead stands declined markedly, probably due to migration, following exhaustion of barkbeetle larvae.

16. Chipmunk numbers showed a remarkable correlation with improved habitat conditions in dead spruce, as reflected by an increase of 221 per cent in time-interval sampling and 225 per cent in snap-trap sampling over the 4-year period of 1949-1952.

17. Trends in white-footed and red-backed mice populations were pronounced and opposite, being down for the former and up for the latter in both stand conditions. This finding suggests cyclic behavior more than response to environmental change.

18. Meadow mice showed a consistently low population in green timber, and a decided upward trend in dead timber, presumably the result of improved food and cover. On the basis of limited sampling, it appeared that lemming mice increased, and shrews decreased, in both timber types, again suggesting cyclic behavior rather than environmental response.

ACKNOWLEDGMENTS

In the execution of this project the interest and encouragement of the U. S. Forest Service was of great value to the investigators. Mr. Ralph R. Hill of the Regional Office, Region II, Denver, and the Supervisors of the White River National Forest and the Gunnison National Forest, provided maps and records of much value to the study and extended, through local rangers, many courtesies in connection with field work.

To the following Game and Fish Department personnel we are especially grateful: Robert R. Elliott, for field assistance in 1952 and for the laborious and responsible task of organizing much of the field data; Jack R. Grieb and Jack D. Remington, who served as assistants in 1949 and 1950, respectively; Ivan E. Jones, for assistance in 1951; and Ladd G. Frary, who aided with the 1952 check at Trappers Lake. Finally, we acknowledge the support of Director Thomas L. Kimball and Mr. Gilbert N. Hunter during the various stages of the investigation.

For criticisms and suggestions leading to more effective presentation of this report, we are indebted to Professors J. V. K. Wagar and Charles Terwilliger, Jr., of the School of Forestry and Range Management, Colorado A & M College, and to Logan J. Bennett, Durward L. Allen, and Daniel L. Leedy, Branch of Wildlife Research, Fish and Wildlife Service, Washington, D. C.

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DISCUSSION

DR. DEVOS: Thank you, Dr. Yeager.

This study certainly shows how remarkable changes can take place as a result of beetle kill. I might say that similar changes have occurred in Eastern Canada as a result of a spruce budworm outbreak among balsam fir.

Obviously, the results of studies such as this one by Dr. Yeager have very good value, immense value to the work of the average wildlife manager.

Are there any comments or questions on this paper?

Dr. Leopold, would you like to say a few words about this?

DR. LEOPOLD: I was very much surprised, Dr. Yeager, that you did not notice any response yet in the snowshoe hare population. Somehow, it would seem to me that a transition to this very open stand of ground cover is bound to have some effect, presumably good effect, at least in the long run. Could there be a cyclic phenomenon here which might be obscured?

DR. YEAGER: That was also a surprise to us; but figures, so far, show very little change as far as we can interpret the data on the population of snowshoe rabbits. I do not know the answer; I do not know why. We were forced to go by observations, of course; we had to go by time interval and strip counts in obtaining the information we had and, also, to a limited number of pellet counts on quantitative samples.

But, as far as we know now, there has been very little change in the population levels of snowshoe hares. We hope to find out why later on.

DR. DEVOS: May I thank you very kindly for your very active participation in this morning's session. We will declare this session closed.

TECHNICAL SESSIONS

Wednesday Morning—March 11

Chairman: J. J. Shomon
Chief, Education Division, Commission of Game and Inland Fisheries, Richmond, Virginia

Discussion Leader: Farley F. Tubbs
Division of Education, Department of Conservation, Lansing, Michigan

CONSERVATION EDUCATION

ALL-OUT EDUCATION FOR ALL-OUT CONSERVATION

Chester S. Wilson
Department of Conservation, St. Paul, Minnesota

Effective methods of conservation education are now well developed but limited in application. Being an administrator, I shall leave methods to the professional educators and public relations experts. The chief concern of administrators is how to marshall and direct the forces of education for maximum results in conservation.

In a free country all progress in public affairs depends on education. What the country needs is an all-out program of education to promote an all-out conservation program. The public must be shown in order to get action.

The imperative need for an immediate and far-reaching expansion effort is shown by the Paley report *Resources for Freedom,* the report of the Water Resources Policy Commission, and other publications. Following are salient facts that must be faced:

(1) The population is rapidly increasing, and the demand for essential materials to maintain a progressive high standard of living is increasing faster than the population.

(2) The immediate demand for essential materials is further increased by the requirements for national defense, for fighting the

Korean War, and for aid to allied free nations in the present world struggle with totalitarian nations for supremacy. If this situation should spread into total war, the need for materials and the drain on resources would expand beyond all previous experience.

(3) Under these drains available non-renewable resources (minerals, etc.) are steadily shrinking—in some cases the supply is critically short. This will result in heavier future demands on renewable resources (products of soil, water, and forests).

(4) Under these drains the available renewable resources (soil, water, and forests) are steadily declining. In spite of all past and present gains in conservation, the forces of depletion are still outstripping the forces of replenishment.

(5) The reserves of undeveloped renewable resources that are usable by present methods (especially land and forests) have dwindled to the point where they are no longer sufficient to meet increasing demands, as in the past. Furthermore, the limited reserves remaining are less accessible than those already developed and cannot be tapped readily on short notice to meet an emergency. With all due allowance for the achievements of science, there is no reasonable prospect that impending shortages of essential materials can be adequately met by technological exploitation of previously undeveloped resources. The major part of the burden must still fall on the land, water, and forest resources already developed.

(6) The major part of our available land and forest resources is in private ownership, including a vast number of small individual holdings. The actual use of water for purposes of production is also under private control to a large degree, though water is not so extensively reduced to private ownership as land and forests. With full credit for all progress in conservation up to date, the bulk of these private holdings are still suffering from depletion and are falling far short of potential production. (The Paley report says that not more than one farm in 50 is under complete good management. Private timber holdings are likewise below par, according to U. S. Forest Service reports.)

All this handwriting on the wall gives warning that, in order to maintain our standard of living and insure survival of our free way of life, we must move at once to bring the management of the great bulk of private land and timber holdings (along with public holdings) up to the standard of maximum perpetual sustained yield. This is a difficult goal, but nothing short of it will suffice. It can be attained by feasible methods already proven in actual practice but not widely applied.

There are only two ways to bring about the necessary action: compulsion or persuasion. Complete compulsion (through government ownership or regimentation of all the important means of production, as practiced in totalitarian countries) is unthinkable here, for it would mean the sacrifice of freedom. The only alternative is persuasion, which means education.

So the forces of education in this country now face a staggering task with three major objectives:

(1) Inducing over 5,000,000 private land and timber owners to adopt conservation and management methods that will meet the standard of maximum perpetual sustained yield;

(2) Inducing the people everywhere to cooperate in personal conservation practices (stopping waste, forest fire prevention, law observance, safety precautions, etc.), and in supporting the general conservation program;

(3) Inducing Congress and the state legislatures to provide the means for effective protection, development, and management of public land, water, and forests for maximum perpetual sustained yield, also the means and services necessary for promotion of the conservation program for private owners and the general public.

In short, education must become a dynamo to generate the motive power for the whole conservation program.

To attain these ends there must be implanted in the minds of people generally an appreciation of their dependence on natural resources and a sense of their moral obligation to husband the means of existence for their fellow men and their posterity. If the right of private property is to continue, the owners must realize that they are not the absolute masters of their holdings, but trustees for the benefit of the public and posterity so far as necessary for the general welfare and the survival of the race. They must recognize as binding the principle of the parable of the talents—that the privilege of holding property depends on keeping it productive. There must be general acceptance of a moral concept that might be expressed in a new comandment, "Thou shalt not waste the substance of the earth, but conserve and replenish it from generation to generation."

But inculcation of general principles is not enough. The conservation education program must be aimed at specific objectives and specific individuals or groups. Carpenters build houses by hitting nails on the head, not by pounding the boards. The educational process is not complete until it has reached every individual and every legislative body or other public agency having control of land, water, or forest resources, and has impelled them to adopt the measures requisite for good conservation. An outstanding example of educational material directed at specific objectives is the booklet entitled *Down the River,* with a ten-point action program, published by the Soil Conservation Society of America. The acid test of education is this: Does it create the will to get results?

While promoting constructive action, conservation educators must be continually on guard against complacency and overconfidence. One of the greatest obstacles to progress is the too-prevalent delusion that science will save the world with sunshine and sea water. Millions have starved in other lands, and even in rich America many have suffered hardship because they wasted their resources, and no miracle men came along in time to save them. Anyway, no matter what wonders science may produce, there is no sense in wasting available resources, thereby reducing the means of existence and endangering the future of the race.

Another example of a dangerous delusion is that the soil conservation problem is practically licked because a major part of the farm land in the country is now embraced in soil conservation districts. Of course this is an important step ahead, but it doesn't mean that all the farmers in the districts have adopted soil conservation plans. All honest and competent experts will agree that as yet only a small percentage of our farm land is under really good control. The biggest part of the job still lies ahead. Here is the challenge to conservation education.

Up to this point we have considered the problem from the standpoint of human existence. That, of course, must come first. However, there is much more at stake. We seek not merely a bare existence but a full measure of "life, liberty, and the pursuit of happiness." A prime requisite for happiness is recreation. Here our wildlife resources enter the picture, for they provide one of the most important means of recreation and also contribute materially to our economic welfare. Wildlife, like human life, depends on good management of soil, water, and forest resources. So wildlife in relation to human happiness and welfare must have its due place in the conservation program.

Education for conservation is just as vital as preparation for national defense, because the survival of the nation depends on it. We have a nation-wide civil defense organization, in addition to a vast military establishment, to protect the country against aggression from without. Yet we have no such national system to protect the country against deterioration from within. Doubtless we need one, but we cannot afford to mark time while waiting for it to be created. The immediate challenge must be met by marshaling the available forces of all existing public agencies and private organizations to join drives in developing and executing a full-scale conservation education program covering every section of the country.

Much has already been done for the advancement of conservation education on a national scale through the National Committee on Policies for Conservation Education, the National Association for Conservation Education and Publicity, and other organizations. What is needed is more power to expand this effort and get it out faster to more people. That power should be provided by the large conservation organizations affiliated with the Natural Resources Council and having branches throughout the country, coordinating their activities as they may jointly determine. Federal and state conservation agencies should lend all possible assistance.

Leaving the general-staff work to these organizations and agencies, here is a working plan for promoting all-out conservation education in every part of the country where an adequate program is not already in operation.

(1) Get all sportsmen's clubs and other conservation organizations, farmers' organizations, soil conservation districts and associations; chambers of commerce, service clubs, women's clubs, parent-teachers' associations, councils of Boy Scouts, Girl Scouts, Campfire Girls; 4-H Clubs, Future Farmers of America, and other youth groups; church clubs or societies (both men and women), and other organizations concerned with public welfare to appoint standing conservation education committees. The main functions of each committee should be:

- (a) Arrange systematic conservation study programs for its own organization, including participation by members as well as outside speakers or instructors.
- (b) Write letters on timely conservation subjects for publication in the readers' columns of newspapers and magazines, and enlist other members of the organization to do likewise.
- (c) Cooperate with similar committees or other organizations in the joint program next described.

(2) Organize in every county or other designated area a joint conservation education council, composed of the chairmen of the local organization committees before described. Separate councils may be advisable for the larger cities. The main functions of each council should be to:

- (a) See that standing conservation committees are formed by all local organizations that should be interested, as before described, and help them in lining up their conservation study programs and getting speakers and material.

(b) Send delegations to visit the boards or other governing bodies and the superintendents, principals, or other administrative heads of all public, parochial, and private schools in the area; urge them to provide adequate conservation instruction; and help them get necessary funds, facilities, and materials.

(c) Send delegations to visit the regents, trustees, or other governing bodies, and the presidents, deans, or other administrative heads of universities, colleges, and other higher educational institutions of every kind in the area, and urge them to make adequate provision for conservation education as follows:

—In all institutions, provide for instruction of every student in the essential elements of conservation;

—in teacher training institutions, provide effective training for teachers in methods of conservation education;

—in professional or technical schools, provide effective training for appropriate lines of conservation work;

—in all institutions, conduct effective research in appropriate conservation fields.

(d) Send delegations to visit the editors of newspapers and magazines, and urge them to publish news, editorials, and articles relating to conservation; likewise to the managers of radio and television stations.

The features of this program which take the message of conservation to older students and adults are especially important. In many schools the younger boys and girls are getting good conservation instruction, but we cannot wait for them to grow up. We need action in effective conservation now. It is not enough for a university or college to offer elective courses for conservation teachers or specialists. Every student—whether in science, arts, law, medicine, or what not—should get the essentials of conservation, so that he will understand that his own and his country's future depends on it, and will be prepared to take an active part in supporting it as soon as he gets out in the world. And the word of conservation must also go direct to men and women in the active walks of life by every available channel of communication.

This is a ground-level program. It is much like a political campaign, where the most effective work is done by precinct committees and workers who come in direct contact with the people. The principal function of national and state agencies is to see that all local areas are covered and that local workers are on the job. However, local orgnizations or agencies need not wait for directives from higher up. They should go ahead on their own initiative.

There is nothing new about this method of operation. What is needed is intensive effort to carry it out in every state, county, and community in the country. If there is anyone so fatuous as to believe that the conservation education program is already up to par anywhere, let him ask himself these questions:

(1) Do all members of Congress and our state legislatures support effective laws and vote adequate funds for conservation?

(2) Do our people everywhere do what is necessary to prevent waste of natural resources and to protect and develop them for maximum perpetual sustained yield?

Until these questions can be answered yes, conservation education is short of its goal. The task is never-ending, for each new generation must get the word. Long ago it was said, "Eternal vigilance is the price of liberty." Now we know that unceasing diligence in conservation is the price of survival.

DISCUSSION

CHAIRMAN SHOMON: I wish we had time for a discussion now of Mr. Wilson's paper; but, unfortunately, he has to leave. So, we will dispense with the discussion until after the reading or the presentation of the second paper.

At this time, I would like to present a young man who is doing a swell job in conservation education in the fine State of Missouri. Most of us who are in conservation education work sort of look up to Missouri and the fine and splendid program that they have in that part of the country. We are very fortunate this morning to have with us the editor of that splendid publication, *The Missouri Conservationist,* and also the Chief of the Education Division for the Missouri Conservation Commission.

It is a pleasure indeed to present to you a personal friend, Dan Saults.

NOT JUST WHAT: WHY?

DAN SAULTS
Missouri Conservation Commission, Jefferson City, Missouri

There is an old, dull and partially untrue axiom of the newspaper business which says every story lead should tell the reader *who, what, where, when* and *why*—leaving out, for the sake of alliteration, *how.* For all its weaknesses, this rule of news writing was sound for beginners in my day, and it is sound now.

We are just beginning to learn something about conservation education, and perhaps we ought to analyze our efforts in terms of this rule of newspaper leads. Our stories, publications, schoolroom approaches, exhibits, radio programs and other efforts at education are always being measured, of course, but we use yardsticks of many dimensions: the inchage of newspaper colums we get printed, the number of copies of our state magazines, the number of employees in our departments who are charged with that vague mission called "Information" or "Public Relations" or "Education."

I suggest that these yardsticks are too preoccupied with bulk. We haven't honestly tested quality—in fact, we don't even know how to make that test. I submit that the name of your department may have appeared in 50 per cent of your state's newspapers this week, that two of the largest papers may have carried photographs with your byline on them—but that this doesn't prove you've educated anyone in either conservation as an abstraction or in the practical application of getting needed work done. I argue that getting an article in one of the big outdoor magazines about the sterling qualities of womble hunting in your state is not selling any principles except those of *tourismo.* I protest that you have no right to feel smug because an outdoors radio program on a national hookup spoke highly of the ease with which gouge-finned prickletails can be taken from your waters. I doubt that figures showing umpteen visits to schools by your men prove the youngsters now understand the complexities of ecology.

These things are not conservation education. There's no use pretending they are.

Let's go back to *who, what, where, when* and *why.* Most of these are easily answered. *Who* are we shooting at with our education programs but the people of our state, young and old? *Where* are we aiming it? At people in general, but with particularly careful sighting at the hunters and fishermen, on the rather logical grounds that they pay the bill. *When* do we pull the trigger? That's whenever the public gets in front of the gun.

But *what* kind of ammunition are we shooting? You've heard that hashed over in these conferences pretty freely. At last September's meeting of the National Association of Conservation Education and Publicity, we did a lot of work on *what*. We asked: *What* kind of work are we doing in conservation education? Here it is, nutshelled:

We're feeding "news" releases to the press, in weekly "letters" or in wildlife columns. We're putting out monthly, or bi-monthly, or quarterly magazines—some of them slick and cleverly done, some with about as much appeal as a mimeographed monthly activity report, some scholarly and dull. We are firing broadsides of varied publications—some of them aimed at impressing possible readers with an understanding of, and solution to, a problem; some of them aimed at pure prestige within a select circle; some of them solely to impress technicians in other states. We are putting on "exhibits" at sports shows, urging more people to hunt in the old Commonwealth of Micropterus—and, at the same time, we are putting on "exhibits" at our fairs urging more farmers to raise the game that is so lamentably short we have to tighten our regulations because there are too many hunters. We are working at TV vaguely, wondering just what to say. We are firing a scattergun of publicity in all directions. That's our *what*.

And, contradictory as it may seem, while we apparently agree that most or all of these things *have* to be done, most of us feel they are not being done well enough. So we continue to debate techniques, angles, ideas, theories and possibilities.

I think we feel a little lost, unsure of ourselves, because our conscience, collectively and individually, is harassing us on this *what*. We aren't satisfied with our efforts in this line—because we have never answered the ultimate in self-searching: *Why* do we deal in conservation education at all?

If our main ultimate purpose is to encourage hunting and fishing we might as well get rid of our Information-Education divisions, quit this nonsense about schools and monthly magazines, drop our pose of preserving posterity. Let's just hire a good outdoor writer to do a free weekly column for the newspapers, get the tackle makers and gun builders to subsidize a hunting and fishing instructor to travel about the state, and buy advertising space.

If, on the other hand, our primary aim is to extol the virtues of our own department, let's throw "education" out the window, quit being pious and hire a good firm of soap hucksters. This will cost a hell of a lot more but the job will be done better. You can even have your own singing jingles this way and, presumably, everyone will buy you. Just about everyone believes in the virtues of the Marines, the Air Force, cigarettes, and chlorophyll toothpaste.

We can afford a good firm, too. Thorstein Veblen believed that the ideal of advertising is to offer everything and deliver nothing. That's just what we would be doing, and we could dispense with research and science, to pour those funds into soap operas extolling the virtues of chlorophyll-packed, vitamin-fed bluegill in the large, economy size, for sale at every licensed pond. And be sure to look for the director's sealmark; none genuine without his personally signed gill-tag.

This may be a bitter and somewhat unfair attack on modern advertising techniques. But we aren't selling super de luxe widgets on easy payments; we haven't any choice and easy answers to offer. We're trying to sell a code of ethics, and we want a whole country to buy it. And that's *why* we must develop a better system of conservation education; *why* we must decide what's really worth doing in that field. We can't compete on equal terms with soap operas and still pretend it's educational.

We must stop the self-delusion by which, as a natural consequence, we also delude the public. Resort publicity, no matter how presented nor how glibly excused, isn't conservation education. Efforts to induce more people into any given area so they will spend money there isn't "information." These things are advertising, and should be treated as such. They should never be confused with education and information. I grant we must compromise on this in the name of expediency, but let's not try to fool ourselves on the subject. Self-delusion is the path to lunacy. And there is enough madness abroad right now even in our own field. But let's ponder further.

Conservation education cannot be based upon an effort to make every citizen a naturalist and every child an embryo zoologist, though sometimes this obvious conclusion has been forgotten in our educational activities. We can and should lead gently into certain backgrounds of conservation; in fact, this is necessary before we can discuss game management intelligently with our customers. A certain amount of rudimentary understanding is vital; there's no point in writing for people who are illiterate, conservation-wise. But there's no use pretending we can raise 100 million people to a technical level!

Much of the material put out in the guise of "conservation education" for the public assumes that public already knows certain principles and certain terminology. Too many writers insist upon retaining the precious purity of their technical phrases in the name of "precision," when they are—or were up to that point—trying to reach people who are interested in bass or, more probably, just fish. You can't educate by losing contact. At the University of Missouri, Werner Nagel of our Commission staff is teaching a one-hour course to graduate students in wildlife management to implant that in their minds. His lectures of last semester should be required reading for all people in this field.

I've been assuming we have agreed that conservation education is not confined to grade-school moppets, that it is aimed at adults also. The background is fully as important a teachment for grownups and there isn't even much difference in technique. As an example: Jim Keefe of Missouri's Commission wrote a basic conservation booklet aimed at junior high school students. It was a simplified capsule of basic causes; we almost concluded it was *too* simple.

But we did print it, with what you might call "mood" illustrations. It appeared in mid-Spring, too late for school distribution, so we sent a few sample copies to outdoor writers and newspaper editors on our "B" list and decided to wait until school reopened to get it to the boys and girls. By fall our original printing of 25,000 copies was exhausted, in the most spontaneous demand for a printed item that I've seen in my six years with the Missouri Commission. Adults got hold of that little 16-page book and thought it was wonderful; it explained so much.

So that's *why* we have to do these basic, simple jobs: in order that people of any age can understand what we are trying to do in the more specialized line of wildlife management.

A couple of years ago, we asked ourselves in Missouri *why* we put out only 10,000 copies of a publication designed to educate the public —and then didn't get it in their hands but made them come seeking it. So last year we printed a quail book, *Whirring Wings,* written by Jack Stanford. We decided that our answer to the inevitable question was that it would acquaint people with Missouri's most famous game bird—not as a living clay pigeon but as a game species dependent upon what man himself did.

Now this was going to be a 96-page book, highly illustrated and thus quite expensive. It might have been superficially logical to put out a limited run and be choosy in placing the book. Yet *why* were we putting it out at all, except to inform people who might do something about providing quail habitat? So we printed 80,000 copies—which reduced the *unit* cost considerably, by the way—and then we tied distribution in with the showing of our new quail movie, *Bobwhite Through the Year,*—and then we tied in our radio programs on a campaign for food-and-cover plots, while announcing the movie and the booklet. We literally forced that book on people who seemed to have even a glimmer of interest.

We had to buy extra copies of the movie to meet the demand; and we'll have to reprint *Whirring Wings* in July. And it all used up budget money that might have been spread around further. But our why-do-it-at-all query indicated it had to be done big—or not done right.

Now let's carry our probing a dangerous step further. *Why* do we have research? *Why* do we journey from Canada, Mexico and most of the states of the United States to compare notes? *Why* do we use, in conservation, the trappings of science? Basically, because all of us are seeking new ideas and information and techniques in conserving and restoring wildlife and forestry resources, resources that belong to that vague body we call "the people." And yet, in the last analysis, only those same "people" can do the actual work of conserving and restoring. Not one state represented here has, or under a democracy will have, enough power and money to order the needed management done on a statewide scale, no matter how much it may need doing.

So *why* hunt for the solutions to conservation problems—unless the people themselves can be told how and *why* to do them for themselves. And that final answer to *why* is the sole excuse for your Information and Education divisions, your public relations sections, your education work. And that is also the most basic explanation for everything else we do in the conservation field!

We must give people Truth, which is something more than an assemblage of facts. We must develop in them a philosophy, if conservation is to be a true mass movement instead of another government agency. We must give them leadership that will develop volunteer leaders at local levels. We must set up an ethical standard within the body of society that will form a new measurement for social approval. We must realize that conservation cannot disassociate itself from any of the other social forces moving man in his daily routine. We must remember that we can do relatively little about managing wildlife unless we can do a great deal about managing man's manipulation of the earth on which all life exists.

And this, I think, is the *why* of conservation education; *why* we must have it, expand it, develop it into a primary force.

Let's always ask ourselves *why* we do what we do in conservation —and make it an honest question to which we must apply an honest answer.

DISCUSSION

MR. TUBBS: Ladies and gentlemen, we have had some challenges thrown out by Mr. Wilson and Dan Saults. Can a democratic type of government function if people do not understand? I like to refer to conservation education as taking all the technical phrases and so on and making it up into an ingredient that people can digest—I prefer to call it pablum—so that the people can incorporate conservation in their thinking. Now, we would like to have anyone who has a question to ask to rise to the occasion at this time.

MR. PARCELL (Hamilton, Montana): Four years ago a child was born to the Montana Federation in the form of an educational program, which I think, was presented to this body in the Sixteenth conference. It was an adult education program and was headed up by a man by the name of Tom Messelt, who may be in this audience now.

In the past four years, I have not only been a recipient of this educational program, but have also taken some active part in putting it across. It is simply this, in a nutshell.

A ten-lecture course emanating from the Public Service Division of the Greater University brought out directly on the ground to the clubs through the medium of this course. And through this course, I have found in my own community, right down at the grass roots, that it has stimulated a desire among farmers, sportsmen, everybody who attended these meetings, to reach out and grasp for additional information, additional education, additional self-broadening in the conservation field.

As a result of that, our own local clubs sponsored an educational committee which has since developed programs of panel discussions that would take up such major issues of conservation as they were interested in locally.

And through the medium of these panels and this educational group who made it a point to give all the informative material that they possibly could get and feed that panel by bringing in experts and getting them on that panel, we have done, I think, one of the finest jobs of adult education, as well as some child education, in that group of getting the essential facts, the things that we need to know in conservation education, and for the management of our lands.

It seems to me that this would be a medium of approach to get the job done that would be a fine gesture if the national body would sponsor such a thing and each state federation would sponsor such a program through the public service division of their own universities in higher education. Thank you.

MR. TUBBS: Thank you, sir.

MR. ROLAND CLEMENT (Rhode Island): I would like to ask Mr. Saults what proportion of his Conservation Commission funds are restricted to receipts from hunting and fishing licenses?

MR. SAULTS: Mr. Clement, our Conservation Commission is supported solely by hunting and fishing revenues. Under our state constitution, all funds spent for hunting and fishing accrue directly to the Conservation Commission. Under the constitution, they must. That is our only support, with the exception of relatively small funds for fire control and so forth.

MR. CLEMENT: So there is no considerable proportion from the general fund?

MR. SAULTS: No, not at all.

MR. CLEMENT: That is surprising, because in my state the restricted receipts are only approximately 45 per cent. And it is my feeling that one of our difficulties in carrying conservation to the public in general is that we continue to equate conservation with fish and game.

And, of course, we all realize, those of us who were trained in this field, that nowadays wildlife management is really landscape management. And it seems to me that one of our problems is to begin talking about landscape management, which is something the general public might be more interested in and understand instead of simply fish and game, which will naturally interest only a minor part or fraction of the whole public.

MR. SAULTS: It is my impression, Mr. Clement, that a good deal more of the public are interested in fish and game than they are in landscape management.

MR. CLEMENT: Of course, I do not mean that in the technical sense now. I mean an interest in the whole out-of-doors, including soil conservation, for industry and water management. In other words, the proper land-use practices that we are all interested in. But apparently it does not apply in your case. I can see that you are justified in emphasizing fish and game if all of your funds come from that source.

MR. TUBBS: Mr. Clement certainly hit right at the heart of the conservation education program, in that there is rapidly taking place a crystallization of thought regarding what conservation is.

It is still a rather obvious misnomer, but nevertheless, there is beginning to be this belief anyway that we cannot handle these things by segmentation. Sooner or later they must be pulled together and treated pretty much as the whole environment process rather than by the various segments that we are used to dealing with in our conservation programs.

DR. PALMER: (National Wildlife Federation): I think I would like to carry your idea a little further and suggest that possibly we emphasize conservation of rural resources and have not taken into consideration that there are problems concerned with urban situations that have been woefully neglected. I might mention that one of the big yearbooks in conservation which we have within the last few years proposes for city conservation education in the school program that children go out and find out whether or not their pastures are overgrazed. I rather question whether those children know anything about pastures or grazing. And I am quite certain that our program must sometime be moved, not to add more content necessarily, to what we give these children, but to changing their habits so that what they do makes it possible for man to get more from the land which he lives on.

I am quite certain that one of the blind spots has been this matter of urban education. I have not heard anyone suggest it this morning. I don't know whether any other of the prepared papers has it. That is, to my mind, one of the blind spots. You can get urban people in the habit of doing things, in helping our problem. Then I do not think we will need to worry about getting their support If we make a program designed solely for management of rural land and ask the city people to come through and support such a program, I think we are getting into difficulty. That is just one idea. I have some others.

I think if we knew what is going on in hunting as a whole, we would realize that there are being formed very considerable groups that do exactly what the speaker had in mind. Possibly it is because we have not gotten people informed about it. But the Federation this year has underwritten some 24 state projects which have not only helped the individual states, but have helped neighboring states as well.

I think there is the machinery underway now to expand that program very considerably, serving two functions. One, a program which is applicable to the state involved; and another, a program which presents the opportunity for that state to serve the whole program generally. We are doing that in the Federation through our workshop grant-in-aid program in the first situation; and in the second situation, through our fellowship program, which provides a broad service rather than the more immediate service. I think that if we knew more about that program, you would realize that we are making progress, and the progress would become less as time goes on.

MR. TUBBS: Doctor Palmer has thrown out some very interesting challenges also. I think we are going to face up to a lot of challenges today; whether or not we devise the methods of overcoming the resistance is certainly going to be hard to say at this time. But anyway, Chester Wilson referred to the continual inventory that is necessary, the research, and then the education and also brought in the esthetic side. And one of the interesting things in the esthetic side is that possibly through that we have a means that we can use to get at the urban people.

If we can tune the facts to the emotions, maybe we can make more rapid progress than if we tried to strike at the emotions of the urban people by sticking strictly to the facts. I see that our time for the discussion period for these papers is drawing to a close. So, now, I will turn the program back to Mr. Shomon.

CONSERVATION EDUCATION—THE KEY TO RESOURCE MANAGEMENT

WILLIAM W. HUBER
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INTRODUCTION

The field of conservation education is a large one. It includes among other things the art of dealing with people. As the competition for our natural resources gets greater and the clamor for the taxpayer's dollar gets louder, it is necessary for the wildlife manager to put his "best foot" forward. The public must be sold on conservation education, or much technical effort, many years of scientific research, and lots of sound management practices will go for nought.

The key to successful wildlife management in any state lies in an informed and cooperative public. In some states we find good progress being made to secure this informed public. In other states there is constant bickering, with the sportsmen out to "get" the game department. Many game directors have as short tenure in office as unsuccessful football coaches. The difference is in the knowledge the public has in the elemental facts of wildlife management and in the objectives of the department.

THE PUBLIC COMES FIRST

The conservation program that forgets the people is doomed to failure. Only those game departments that have good conservation education programs are successful in harvesting the maximum crops of wildlife that are being produced in their states. Many fish and game departments are still struggling along without adequate conservation education divisions, and they will struggle in vain until they bring their problems to the public in such way that the public can understand them. Other conservation agencies are facing the same situation.

A division of conservation education, public relations, or information is a step forward, but everyone in the agency needs to be trained in public relations work. Oregon has fine departments of fish and game, but the state police are the game wardens. Closer cooperation between the agencies is helping sell the departments' programs, but much misunderstanding resulted before the programs were correlated.

The responsibility to the public in wildlife management becomes more complex when consideration is given to the multiple-use nature of the land involved. Seldom is more than a small percentage of the land devoted to wildlife alone. As more water and land areas are taken by other uses, smaller areas will be devoted to wildlife use, and conservation will need many friends. Selfish groups that are only interested in what they can get for themselves, whether it be in dollars, pounds of fish, or wild meat, are never a help. Rather, these groups are detrimental to any well-prepared program.

Conservationists can be of great help if properly informed, but it takes more than one man preparing releases for the press, magazines, radio, or television for any agency to get information to the people who need it. The division of conservation education can guide the educational work, train the personnel of the department in use of media, but it cannot do the entire public relations job. Even with everyone in the organization fully informed, you find individuals totally unable to get information to the people without causing friction. Few organizations have places to hide these unsociable public servants, as even the laboratory is now open to the public.

THE COLLEGE STUDENT IN CONSERVATION

As conservation is made up of many sciences, many colleges are involved in training students for their life work in the conservation field. The raw recruit in these colleges is usually an individual who loves the outdoors and all the wild things and creatures that live in the forests, fields, and streams that make up these lands and waters. Perhaps he has been persuaded to study conservation because he is a good hunter or fisherman—and perhaps because in high school he didn't like English and didn't show too much aptitude toward psychology, philosophy or public speaking. In college he may again try to eliminate these subjects to concentrate on botany, zoology, chemistry, and physics. These courses are all essential and desirable, but the ones that are passed over may be the very subjects that the student needs. The students in the conservation field are the future protectors of our natural resources. They must meet the public and gain public support if we are to use these resources wisely. These students will soon take their places wth the leaders and molders of public opinion who are selling the public in this great democracy. It is one of the greatest sales jobs in history, with pressure groups, political maneuvers, and other antics used to sell the American public.

With higher-paying jobs, industry has the jump on public agencies. They strive for the best public relations men. Many industries are doing a commendable job but have a tendency to be overoptimistic about the source of raw materials. This can hurt conservation, as it has a tendency to confuse the issue and leave the public wondering what is right and what is wrong. Are industrial wastes polluting streams, or is the situation under control? Do we need to drain the swamps? Are we, as a nation, growing as much timber as we are cutting? The graduates of the conservation colleges know the answers to these questions, but many cannot get this information to the public.

THE RESPONSIBILITY OF COLLEGES

The colleges of conservation, whether wildlife, forestry, range, or water management, should include such courses as English, public speaking, psychology, sociology, and personnel management.

Some attempt should be made to get graduate work into the more practical fields. The desire for education has reached such a high level that students are no longer satisfied with the A.B. or B.S. degrees. They now desire masters' or doctors' degrees and in the field of wildlife management many of these can only be obtained after the graduate student has worked out the life cycle of a tapeworm found in the Block Island meadow mouse, or the reaction of the pancreatic juices of the white-chinned shrew. This desire for scientific facts is no longer based on the pressing needs of our dwindling resources but rather on the desire of technically trained men to impress others with their knowledge. Many of our professors are responsible for this misplaced yen for impractical scientific knowledge. Too few of our teachers have training in practical fields. Many live a life of degrees and graduate from student to teacher without having practiced what they preach. A student with an analytical mind should be encouraged to get practical experience and then return to college for higher degrees.

The search for scientific information is essential in all fields of conservation. The needs for these scientific facts with practical application are so great in the proper management of wildlife that we are only scratching the surface of the mysteries of this renewable natural resource. The application of facts to practical problems far outweighs the importance of the more remote scientific investigations that seem to attract wildlife technicians. *The Journal of Range Management* is a scientific publication that deals with practical matters. Many stockmen belong to the American Society of Range Management and have profited from the publication of this journal. Many other journals are so technical in scope that some of the professionals in the field have dropped out of the parent organization because they do not care for the material presented.

The field of conservation administration is wide open. Men with college educations are needed. There is also a need for men who are specialists in research and who have been trained in the scientific approach to conservation problems. But every graduate cannot be a good scientist. and some system of segregation of graduates into administration and research should be made at college level, if possible prior to the junior year. It may be disheartening to college graduates to find they are not cut out for research work after accumulating several college degrees. But it is tougher to spend thousands of dollars on some problem and then come to the conclusion that the wrong man is conducting the experiment. The need for well-trained administrators is great, and colleges should concentrate on turning out as many graduates for this field as possible. The need in the research field is definitely limited to quality, not quantity. But whether the field of wildlife management is run by poolroom game wardens, good administrators, trained biologists, or half-baked scientists, the end result is secured only after selling resource management to the public.

John F. Dequine, of the Game and Fresh Water Fish Commission of Florida, concludes in the paper he presented in the July, 1952, issue of the *Progressive Fish Culturist*:

> The modern fishery manager cannot confine his activities to gathering facts, drawing conclusions and making recommendations. He must, in addition, become a salesman and an educator if he is to accomplish his objective, whether it be removal of an unnecessary regulation, adoption of a new program, or other.

The Outdoor Writers' Association of America at its annual meeting at Miami, Florida, and later at the western divisional meeting at Glacier Park, Montana, passed resolutions stressing the importance of getting the facts neecssary to carry on sound management of the wildlife resources, and in presenting these facts properly to the public. The western division of O.W.A.A. recommended that at least 5 per cent of the state fish and game departments' budgets be used to disseminate information and education.

NEW EMPLOYEES IN THE CONSERVATION FIELD

When public agencies in the conservation field hire a new employee, this employee is put through a training period of varied duration, depending on the agency. In general, this period is for one year. During this probationary period, the new employee is given an orientation course in the various activities of the agency. If a neophyte does not fit into the organization, or does not show aptitude for the work, it is a favor to this new employee to discharge him and permit him to try another field of endeavor. Many conservation organizations today are choked with poor men due to kind-hearted personnel officers, who didn't fire the unsatisfactory employee after the probationary period.

It is during this probationary period that training should be stressed in public relations. More men hold themselves back on the conservation-career ladder due to poor public relations than due to a lack of technical knowledge to do the job. The job in conservation education requires that everyone in the field be trained in public relations work and assume the responsibility of keeping up to date on facts concerning conservation so that they can in turn advise the public.

METHODS OF PROVIDING CONSERVATION EDUCATION

Four-year college courses in conservation are now given leading to a B.S. degree in this field. Many colleges have special courses in conservation to train students for future teaching careers in conservation. Colleges that teach forestry, soil conservation, range and watershed management, and many of the engineering and mining schools, give general courses in conservation. Still greater emphasis should be made on the correlation of all natural resources by colleges providing education in any one field.

Many state conservation departments sponsor conservation workshops to interest teachers and community leaders in conservation education. These are fine training tools, and usually present conservation education as an enjoyable study. Show-me trips are taken to soil-erosion projects, timber sales, deer winter ranges, polluted streams, and many other areas that show good or poor conservation. The problem seems to be one of getting attendance at the workshops, and all conservation agencies should aid in creating interest in such programs.

Many conservation agencies publish magazines that are excellent salesmen of conservation education. Virginia, Michigan, Pennsylvania, Wyoming, Colorado, Wisconsin, and New York are a few of the many states that have fine conservation magazines dedicated to the wise use of the natural resources. Many of these magazines bear the title of "State Conservation" or "State Conservationist." Not only is the material in these publications well presented, but the photographs tell a story that in many cases needs no further explanation.

Other methods of getting conservation to the public are slide lectures, motion picture shows, displays, posters, talks, news releases, radio and television programs, demonstration plots, personal contacts, public contests, and many others. Nearly everything wildlife managers do in some way sells conservation. The proper wearing of a uniform is a public-relations tool. A careful driver and a car with the official seal are conservation education instruments. Giving the taxpayer his money's worth in sound resource management is not enough. He must be sold in the present and future program, and needs education to know what is good for him. More conservation can be taught through personal contact work than through any other media. This is why the law enforcement officer is such a key man in wildlife managment. But he must do his job in an impartial manner and show no favoritism. He must be courteous and friendly and not be "sniffing" around like a bloodhound on a hot trail. License checking, creel census work, or routine visits to hunting camps can be the opening wedges to promote needed projects such as a doe season on a depleted deer range, or support for a regulation against carrying a loaded gun in a car.

Active participation in conservation projects by sportsmen, civic groups, ladies' clubs, labor organizations, and others, creates interest in resource management. A program of tree planting in the Tillamook Burn of Oregon by Portland high-school students is sponsored by Izaak Waltonians and other civic groups and is making the sponsoring agencies alert to the many needs in the conservation field.

CONCLUSIONS

1. Many conservation agencies are finding that doing a good job is not enough. The public must be educated in what the agency is doing and what needs to be done.
2. Every individual in an organization should be trained in public-relations work, and in getting the agency's program to the public.
3. Colleges should concentrate on training good conservation administrators and fewer but better specialists.
4. Technicians should prepare their material for public consumption, not for the "self-admiration society" of other technicians.
5. The education of the public to the wise use of the natural resources is the key to resource management.

DISCUSSION

TED FEARNOW (Pennsylvania): I would like to ask if any move is being made to transfer the game law enforcement work in Oregon from the State Police into the Game and Fish Department?

MR. HUBER: Well, there are about three bills now in Oregon's Legislature. However, I do not think that any of them will pass. They are trying to transfer the law enforcement to the Game Commission. But the sportsmen themselves are not organized and do not know just what they want.

There are two groups of sportsmen in Oregon—the Izaak Walton League and the Wildlife Federation. The Wildlife Federation is very strong for transferring the law enforcement to the Game Department. But the Izaak Walton League is a little bit divided and has not actually taken a stand on it. There is a possibility that a bill could pass. But it is a pretty slim one.

MR. TUBBS: Any other questions?

MARGARET KENNETHS (Forest Service): You said it was difficult to get something in the way of cooperation from teachers in attending conservation workshops. I work with women's clubs, and I think Mrs. Byerrum from the General Federation of Women's Clubs could say something about that. I think you can get all the teachers to go who can be financed under their own steam or by an organization. Mrs. Byerrum, do you agree?

MRS. BYERRUM (Illinois): I do agree. It isn't difficult to get teachers to attend workshops. In the last years in Illinois, where I live, all the teacher training institutions have conducted summer workshops for teachers. And we have had 6,000 in attendance during these last years. Women's clubs and garden clubs furnish scholarships for many of them and pay part of their expenses, so that they can attend the workshops. College credit is given for them, and they have been very attractive to teachers.

MR. TUBBS: I might mention that that is a very popular movement over quite a considerable part of the country.

MR. MCALPIN (Michigan): I would like to ask Mr. Huber what part youth conservation education plays in his program or I would like to re-state the term "conservation education" and call it "youth conservation appeal."

MR. HUBER: I think that youth conservation has a large part in any conservation education program. In fact, in Oregon, we are working with the schools, and in the part of my talk, we brought out a project where high school students in the City of Portland, Oregon, under the sponsorship of the Izaak Walton League and other organizations, with the trees furnished by the state Forest Service, are trying to replant that 5,000-acre burn.

MR. TUBBS: There must not be any professors in this crowd. Mr. Huber mentioned a process of sterilization of the mind of all practical use in his discussion, and it certainly should have stimulated some of the professors to rise to the occasion.

MR. FRED CRONEMILLER (California): In approaching this problem of conservation education, I think it may be something like approaching a land or wildlife management problem. And it works two ways. It is psychological. You think of wildlife first as management of the animals. Now, we are coming to think of it as managing the land and getting the relationship between the animal and the land and of managing the land so that the land produces more animals.

Now, in our discussions usually in the conservation education field, we speak of the teacher, the educator, the management, who is dishing out the education; and having had over 35 years' experience in that, I come now to wondering about the reactions of the educatee, the person whom we are driving at; and his reactions in my experience have been quite varied.

In the early days, I think we felt something like the disciples did as was well brought out in the wonderful book *The Silver Chalice,* where they were not popular; but those that were with Him were really with Him. And that was our situation 35 or 40 years ago.

And down through the years, the reaction of the one we were trying to reach has been, as I said, quite varied. I have often envied a lot of people in their ability to reach other people and have come to defining those people as people with an honest face. Apparently I did not have it, because the reaction to my talks were ever so sincere. But I think probably we were talking over the heads of a lot of people that we were trying to bring around to understand these problems of conservation.

My question is not to Mr. Huber but to Mr. Saults; because of their wonderful success in Missouri.

Is there anything he can say on that problem of understanding people and their reactions to our attempts at conservation? So often they just fall on fallow ground with no success. And is there something that we should think about more in the reactions of people to our efforts and how splendid our own efforts have been.

MR. SAULTS: Well, first of all, I would like to point out that we do not claim in Missouri that we have had splendid success. We are far from satisfied in what we have achieved so far. But I think we have this one thing, sir:

As you commented, we originally started out so we could manage game; then we came to the idea that that was not quite so simple; that what we had to do was manage land; but basically the only thing we can manage is people, and ask them to manage the land so that game will be produced. I think we have got to get down to that basic approach to the thing which has the added virtue of making the education program most important of all. But until we manage people, we cannot manage land or game.

CHAIRMAN SHOMON: Earlier this morning, our friend, Dan Saults, said he did not consider himself an educator. Well, in order not to disappoint you good people this morning, we have a man with us who is a conservation educator by title, Mr. John Dodge, conservation educator of the New Hampshire Fish and Game Department.

EDUCATION TOOLS FOR TRAINING IN-SERVICE PERSONNEL

JOHN E. DODGE

Fish and Game Department, Concord, New Hampshire

OVERVIEW

Among educators, it is generally conceded that "workshops" are the most promising method yet devised to provide effective in-service education in conservation for teachers.[1]

Can this technique profitably be adapted to training personnel from our own departments? This paper is a report on the procedures and results of an attempt to apply the workshop process in a genuine situation. It is submitted that educators will find implicit in this record authentic criteria for evaluating the effectiveness of the workshop approach and the type of problem susceptible to its application.

Summary. In March, 1951, all 32 members of New Hampshire's Conservation Officer Force met at a centrally located inn to conduct their own three-day workshop school. Committees involving the entire membership set up the program, determined subject matter most pertinent to their work—including such major areas as law enforcement, game and fish management, public relations and education—and invited consultants from professional agencies and lay groups, both inside the state and out, to participate in their deliberations. Results were so outstanding that these workshops are being continued as an annual event.

Objectives of workshop.

1. To provide effective in-service education at the professional level for conservation officers.
2. To increase *esprit de corps* among members of the officer force, and between them and other divisions.
3. To develop a workable basis for shaping department policies

[1]See "A Report from the Purdue Conference," of the National Committee on Policies in Conservation Education, Sept. 16-17, 1952, page 11.

which represent the best thinking of the entire membership.

4. To involve in the process participating representatives of other agencies and lay groups which share joint problems.

Outcomes of Workshop.[2]

1. Second annual conservation officers' workshop held in March, 1952, redesigned and conducted at the unanimous request of the officers.
2. Permanent "policies committee" of the officers established to hold monthly meetings at headquarters with administrators and the chiefs of other divisions.
3. Subsequent district meetings held to involve all members of the force in sharing the results of these sessions.
4. Direct consultation with all officers effected before changes in fishing and hunting regulations are recommended to legislature or commission—these in conjunction with recommendations from our Management and Research Division.
5. Cooperative approval secured from officers for change in policy to direct activities of our federal-aid biologists primarily toward management projects based on prior research.
6. Agreement reached to use publicity for "spotting" hunting pressure on our deer herd at points where it needs reduction. Cooperation offered by officers in operating voluntary checking stations to secure data.
7. Revolutionary shift in fish propagation policies recommended, which has led to the appointment of a trained biologist as "Chief of Fisheries" to direct a drive for "bigger and better salmonoids." This has produced significant changes in species favored, an increase of 53 per cent in pounds, superior brood stock, early spawning fish, etc.
8. Emphasis demanded on effective management of warm-water game fish and forage fish—which has led to federal-aid studies on bass, reclamation of certain waters for their exclusive use, closer coordination of warm-water fish plantings under the Chief of Fisheries, etc.
9. A manual prepared and furnished to each officer summarizing the consensus of workshop opinion on key problems—with special emphasis on securing uniformity of interpretation, enforcement, and court procedures with relation to fish and game statutes.

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[2]It should be recognized that many of these advances in policy and operation could and would have been promulgated from department administrators or appropriate agencies in due course. It is significant, however, that each has been subjected to democratic study and acceptance by the men who represent the department in each district, and will therefore invoke their maximum support.

10. A united attack on problems of farmer-sportsmen's relations agreed upon between officers, sportsmen's clubs, and farm organizations—leading to a special bulletin from the Farm Bureau soliciting cooperation from its members with the department's program of game damage control, and a Federated Sportsmen's Club committee with effective teams working at a local level in several areas.

STEPS IN SETTING UP THE WORKSHOP

Six weeks before formal sessions began the officers declared unanimously that "the workshop has already more than paid for itself!"

Hence, it is vital to describe the procedures followed in preparing for the event, since these are probably more crucial to the success of such a project than the program ultimately developed.

Definition of a workshop—August, 1950. Three criteria of a genuine workshop were set forth in a letter from our Conservation Educator to the Director as follows:

(1) "Has it been called for and planned by the *men themselves* in answer to their own felt needs and not done *for* them or *to* them?"

(2) "Is there a real set of problems on which the group is working —identified, understood, and accepted by all members?"

(3) "Will it lead to effective action which will affect the problems in proportion to the effort and expense entailed?"

Facing a Need—August, 1950. Since prior to this date our officers had felt only a vague need for "more get-togethers" and some sort of "school," shock tactics were required to start the process. Included in the previously mentioned letter to the Director was the following statement, which when relayed to the officers brought prompt and forceful repercussions:

"For many years the 'warden force' provided the focal point and continuity which determined the long-range course of the department's progress. With vastly increased size and complexity of the department and concomitant increased demands upon individuals for specialized and advanced professional training, this field force must either keep pace or forfeit its key position. This constitutes a serious danger. . . . Yet, to date, the only concerted efforts in behalf of the field force have been of a purely mechanical nature—better equipment, better communications, tighter direction, more money, routine law enforcement skills. . . . As a matter of fact, in the past many of these men have not been qualified to carry out some of the duties for which their classification calls.''[3]

Assuming Responsibility—August 30, 1950. To facilitate meeting criteria numbers one and two the following procedures were adopted:

(1) Five "line" officers of various grades of seniority and one district chief were invited to meet at headquarters to vote—absolutely democratically—on whether a workshop should be attempted, and if so, how.

(2) Since the answer to the first question was a unanimous "yes," it was decided *by the men* that this group should continue to function as a permanent "steering committee"—thus taking top control out of administrative hands.

(3) The district chiefs were to be indoctrinated by their committee member and then asked to hold district meetings and disseminate understanding of the plan to all members of the force.

(4) Each district was then to hold its own "problem census," collecting each man's suggestions of problems for the agenda, which were later to be grouped by the steering committee under four major headings—Law Enforcement, Game Management, Fish Management, and Public Relations and Education.

(5) *Every officer on the force* should be asked to serve on one of seven necessary committees: Program and Organization, Accommodations and Hospitality, Recreation, Law Enforcement, Game Management, Fish Management, Public Relations and Education.

(6) Each committee was to be held responsible for grouping problems for its session, inviting consultants to participate, and operating the session as it saw fit. The steering committee was to take over the work of Program and Organization.

Small Group Work—January 15, 1951. When problems for the agenda had been received from all districts, the steering committee met to set up membership on each committee. Such meetings were conducted according to strict rules of parliamentary procedure, and it was voted to exclude district chiefs from jobs as chairmen of these committees.

Between this date and the opening of the workshop, each committee met at least twice to refine its agenda and plans and to instruct its chairman how he was to proceed.

Planning for Follow-up. To meet criterion number three, it had by this time become evident to participants that many potential values

[3]Our current classification law calls for two years of college or the equivalent and a very specific objective screening of candidates before they are even interviewed by department administrators.

of their work would be lost if they failed to provide machinery for its utilization in subsequent months.

Hence, on the motion of a line officer, the steering committee voted to *delegate back to the district chiefs* the responsibility for acting as a Standing Committee on Policies. Within ten days after the workshop closed, these men were instructed to meet with department administrators and secure acceptance or rejection of all new policies and rulings recommended by the membership, who were to be furnished with mimeographed copies of the results. Manifestly, practical considerations favored this procedure, but the fact that the men chose it voluntarily demonstrates the effectiveness of the democratic process.

THE WORKSHOP IN PROCESS

Strictly in recognition of his personal competence rather than his status, the district chief who had been serving on the steering committee was elected coordinator for the workshop. For the three-day session he acted as moderator, and the many hours of time and thought he gave to preparation were a major factor in insuring its success.

Group Process Techniques.

(1) To evoke maximum participation and involvement among the men, the coordinator recommended that the first half-day session be devoted to having each officer state briefly what he thought were the most important issues to be considered "for the good of the Department."

(2) All these thoughts, as well as those expressed at later sessions, were tape-recorded. This was valuable in giving weight to the contributions, as well as for reference.

(3) The setting was carefully designed. Accommodations Committee men were instructed to select a friendly inn and provide for recreational facilities and a "classroom" in which chairs could be grouped. All officers wore civilian clothes.

(4) Sessions were timed (with buzz breaks) and placed in such order that "Law Enforcement," which the men regarded as the climax, should come last.

(5) The group decided that values to be gained by having all the men participate in each session were greater than those to be anticipated from splitting into small work groups, since that technique had already been employed in getting ready.

(6) The Recreation Committee worked long and hard to arrange for the officers to demonstrate their ability to play together—and came up with a full-dress mock trial that would have done credit to high comedy or the best burlesque!

(7) A final banquet with all the "fixin's" gave administrators, commissioners, and Department well-wishers an opportunity to get in on the show in a constructive manner by making the men feel the significance of the program *they* had initiated.

Consultants. Much thoughtful consideration by the officers led them to recognize that they should select and invite consultants quite as much to promote better public relations as to bring special "expert" information to the group. Each consultant was, therefore, furnished with full copies of the problem agenda for his session well ahead of time and urged to keep his answers short and specific and to *make no speeches.* Consultants for each session were grouped as a panel, led by the chairman of that particular committee, and the officer who had originally asked for the inclusion of a given problem was invited to restate it from the floor.

Hot discussion from the floor challenged each answer. The men quickly learned to keep their questions and statements to the point and in a constructive vein. Thus, panel members were exposed to the genuine thinking of the group rather than a passive audience. Involved as partners and participants in the experiment, they gained new insight into the Department's problems, and maximum learning took place on a two-way basis. A brief statement of actual consultants secured and the role they played may be informative:

(1) Public Relations: The Commissioner of Agriculture, the President of the Federated Sportsmen's Clubs, the legislative counsel for the Farm Bureau. The debate centered around landowner-sportsmen relations, crop damage, trespass laws.

(2) Education: Director of Instruction State Department of Education; President of the Federated Sportsmen's Clubs. "What part should conservation officers take in conservation education in our schools?"

(3) Fish Management: Department biologists and propagation personnel, chief of fish planting. Discussion of habitat improvement and the value of research, rough-fish policies, stream improvement, new propagation and stocking policies.

(4) Game Management. Professor of wildlife management from State University, Department biologists. Debate on techniques and policies concerned with deer management and damage control, beaver, pheasants, etc.

(5) Law Enforcement (all-day session). Assistant Attorney General, President of Judges' Association, a notorious defense attorney, captain and technical lieutenant from State Police. county solicitor. Technical aspects of arrest, court procedure, gathering and presenting evi-

dence. Loopholes in the law, and uniform interpretation. Policies. Use of radio and cooperation between law enforcement branches.

It is significant that many officers previously debated the wisdom of "letting their hair down" before some of these consultants but were completely convinced afterwards. They chose to invite only biologists from our own department rather than "outsiders" from other state or federal services, feeling that these men knew our own problems best.

Press and Public Relations. As indicated, the public relations aspects of the workshop, both inside the department and with other agencies and groups in the state, proved tremendously effective and constructive. Carefully selected members of the press were invited to participate in all sessions and we received wide and favorable coverage, which had a positive effect on several of the problems. It will be noted that no member of the department or of the general public was invited to the workshop unless he had a participating role to play.

CONCLUSIONS

(1) The conservation officers' workshop has proved itself to be a valuable educational device for providing professional training, strengthening morale, and increasing the efficiency of the department's operation.

(2) Continuity of cooperative efforts throughout the year to revise policies and procedures is more effective than a short course or "school" which takes place on an annual basis.

(3) Intensive democratic planning for the first year of such a workshop minimizes the necessity for detailed work in future years. However, the process must not be allowed to become static. For example, our men are now recommending use of out-of-state biologists as consultantants, a new type of problem census, and concentration of effort upon fewer problems at a time.

(4) While responsibility for planning and operating the workshop must rest with the participants, they need trained guidance in applying techniques of education to their situation.

(5) The primary task in initiating a workshop is to convince department administrators that it will pay to subject the policies and operation of their department to frank, constructive criticism by their own personnel and other interested groups.

(6) Public relations of the department are strengthened by involving as participants the most vocative members of the most antagonistic groups with which we have to deal. Internal relations are improved as technical staffs, propagation personnel, and conservation

officers come to understand each other's problems. We find there is a wide unrecognized gap between their viewpoints.

DISCUSSION

CHAIRMAN SHOMON: Thank you for a very excellent presentation. Now, Mr. Tubbs.

MR. TUBBS: Well, folks, we have gone further with challenges. This is certainly an interesting presentation and I am sure it provokes some thought on the part of you folks, especially as you might take it back home and use it.

Let's have a question or two from the floor; and then I would like to give the members of the panel an opportunity to put their fellow men on the spot if they desire.

VOICE: How many in the room have tried the workshop method in bringing about the type of result that he talked of?

MR. TUBBS: Well, there is a sprinkling. It is interesting to note that it has started. Is there anyone at the table who would like to make a comment?

MR. SAULTS: I would like to ask John how much time they allot to the various forms of public relations training.

MR. DODGE: That is a very interesting question. I think the answer was given earlier in this panel by one of my colleagues who said that public relations is a continuing process throughout the year by every member of the department.

There were six months put into this in that we all worked toegther to set this up. There was one-half day put into a professional session which was merely the payoff.

VOICE: I am interested in finding out whether this actually came from a law enforcement officer who wanted to do public relations work or whether it was some opportunity there to convince him that it is worthwhile.

MR. DODGE: If I understand your question, the feeling was certainly there among our officers that they were the public relations department of the State Fish and Game department. They are the shock troops. They get out and take the rap in their own districts. They are the people who receive it from their own public. And that in my opinion is one of their primary functions. There are three things. They are law enforcement, of course, and that is a part of public relations, if it is well done. But, in addition to that, they are game managers in the sense that they carry out the continuous planning for our fish and the watching of our game, calling on the biologists for specialized help, but carrying the ball themselves day after day.

In the third sense, they are doing direct public relations work because our men feel that one of their primary jobs and duties is to be at almost every sportsmen's club meeting, to know those fellows on the street, and to meet the vast public who come in from out of the state to use our game and fish resources.

VOICE: I would like to know if you include your biologists and your fish hatchery personnel in your workshops and all?

MR. DODGE: Nobody is in these workshops unless he is there in a working capacity. He is invited for a specific type of contribution by the people who set up the workshop. I can conceive of a workshop in which the entire department participates. In this particular case, it is the officers' show, and we back them in bringing people in not to look at them, not to listen to them, but to help if they are going to be there.

MR. TUBBS: Everyone must function in the workshop process. If they don't, it is pretty much of a failure.

EFFECTIVE USE OF CONSERVATION EDUCATION BY THE LAW ENFORCEMENT OFFICER

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This paper is presented to explain how the conservation officer can, by applying methods of education, prevent persons from violating the conservation laws. By a planned and organized program of education, much can be done to eliminate the violators from the conservation picture. It is our sincere belief that any law enforcement agency, to live up fully to its duties and responsibilities, must have a sound program of prevention. This program, coupled with police power and adequate penalties for the habitual or repeater-type violator, will eventually bring about the desired results, providing also that the agency has the support of the public, the courts, and the prosecutor's office. It has always been our contention that the police power of the state is the keystone which holds up the broad arch of conservation.

Conservation progress is measured by the extent the people appreciate that wildlife is their property and that no one man has a better claim to it than any other. If this fact were universally accepted, there would be no arrests and certainly no one would charge us with being a conservation failure. The goal of any conservation law enforcement agency should be the maximum protection of resources and people, which calls for a condition where a minimum number of arrests would be necessary. Financial restrictions usually limit the size of the officer force, but we believe the quality rather than the quantity is of first importance.

There are two schools of thought as to what role the conservation officer should play in the conservation program: (1) those who believe the functions of conservation officers should be multiple and (2) those who believe that the officer cannot do a proper job of enforcement if he has multiple functions to perform. We wish to state here that we are in accord with the policy that the conservation officer performs manifold duties, and we have operated under this policy throughout the history of conservation in Wisconsin.

Conservation today is, in its broad sense, a *salesman's* job. With this fact in mind, it is necessary that new recruits have qualifications and requisites that will best fit them for this role of conservation officer. The applicants in Wisconsin must pass a rigid civil service examination. They must be between the ages of 21 and 30, weigh not less than 160 pounds, and be at least five feet, nine inches tall. In addition, they must have received a degree from a recognized college either in forestry, game or fish biology, or related courses applicable to conservation work. Further, they must be of good moral character, emotionally stable, resourceful, tactful, and alert; they must be well developed physically, and are required to pass unconditionally a rigid physical examination given by a physician designated by the Conservation Department. As stated before, they must be salesmen and leaders, and in order for them to make use of these two qualifications, it is of vital importance that they be trained in all policies and programs of the Conservation Department. In addition they must know these three things: (1) the law, (2) the public's rights and (3) their own rights. Good public relations come first with their own conservation department because they cannot possibly have the best public relations on the outside unless they first have them on the inside, and that is why constant in-service training is necessary. Because of their strategic or regional location in various parts of the state, it is necessary that the conservation officers be the interpreters and salesmen for the Conservation Department. In order to carry out this function, it is of dire necessity that they have full knowledge of the multiple programs that are grouped as conservation. With their practical knowledge, coupled with their technical information, the officers are in the best position to dispense and sell the over-all program to the public. With the vast amount of information pouring out of conservation mills these days, it takes well-informed men to put their fingers on those items that have immediate public application. It is recognized that one of the most potent tools available to game or fish management is regulation. Because this is true, it is of vital importance that the officers have a broad understanding and be a part of such management. The officers can be considered one of the important arms of management in their respective areas.

Recognizing that the minds of youth can be guided, provided proper leadership is available, the Wisconsin Law Enforcement Division embarked upon a juvenile-education program. The legislative groundwork had already been laid. Wisconsin was one of the first states in the Union to provide adequate juvenile delinquency laws. These laws provide that the parents are responsible for the actions of their youngsters, and also establish procedure for juvenile guidance and court action. They provide protection for the youngster inasmuch as it is illegal to publish the names of juveniles arrested in this state. There are two phases to this educational program: (1) actual contact in the field when a youngster has violated the law and (2) a planned program which is presented in our schools and to various youth organizations such as junior conservation clubs, Boy Scouts, Future

Farmers of America, and summer camps.

In the first phase of this program, our conservation officers identify themselves and explain to the youngsters the need for conservation laws. They then tell them the basic conservation story. The officers take the youngsters home and meet the parents. They explain our program to them and ask them for their cooperation. In the more serious cases, the youngsters and the parents are brought before the district attorney and juvenile court for whatever action the court and prosecuting attorney deem proper. We suggest to the youths and their parents that the boys join a junior conservation club, the Boy Scouts of America, or if they live in the country, the Future Farmers of America or any other youth organization where proper leadership is provided. Youngsters, as we all know, have unlimited energy, and unless we adults guide that energy along constructive lines, it will in most cases be used for something destructive. The officers also take these youngsters with them when stocking fish or game and utilize their energy in tree planting programs or in helping on game census surveys where they can contribute. By being a part of doing something constructive, their interest will grow and they will not only be better conservationists, but better citizens as well.

In all cases the officers make out a card form which they send to the main office, giving the name and address of the youth and the violation, and report the action they took in each youth treatment case. A complete card file is kept of all juvenile cases as well as adult cases. We write the youngsters a letter pointing out that we need their help, and if Wisconsin is to maintain its leadership in conservation, it is necessary that they too contribute to this program. We point out that our interest in them is one of a friendly nature and that we wish to help them wherever we can. We send them conservation literature prepared especially for this age group and also literature on gun safety, boat safety, and pictures of fish and game native to this state so that they can learn to identify them.

The second phase of this program is in meeting with youth groups, particularly in schools. We teach the students the wonders of nature and appeal to their sense of fair play, pointing out that it is not any satisfaction winning a football, baseball or basketball game if one has to cheat to win, and neither is there any satisfaction in bagging a deer, partridge, fish or squirrel for the same reason. In explaining the rules, we teach them the basic concepts of conservation and try to impress upon them that game and fish are but a by-product of good conservation land management.

The Law Enforcement Division noted that the Forest Protection Division had carried on a successful educational program of forest fire prevention in the schools of this state, and they were the first to inaugurate such a program in Wisconsin. The fine record of the Forest Protection Division in this state is an outstanding example of what can be done through education. At this time the Forestry, Game, Fish, and Law Enforcement Divisions are jointly carrying the educational program to the schools of this state. It is called a Conservation Education Day Program. Our personnel act as instructors in the school for the entire day. In our opinion, this program is ideal for it not only shows the public that we are one conservation department, but we find, in a great measure, it promotes better relationships among divisions.

The records show that we have obtained convictions in the last three years in 99 plus per cent of game law cases. Two circuit court judges in the past year admonished two circuit court juries for failure to find a man guilty as charged by our conservation officers, and these two circuit court judges informed the jury that they would never again be called upon to sit as jurors in their courts, as the evidence presented by our officers was conclusive in their minds that the persons were guilty as charged. The high percentage of convictions plus the attitude of the courts and the public definitely prove to us that the education and prevention program carried on in Wisconsin is receiving public support. A few short years ago, we did not enjoy the above picture in this state, and we attribute, in a great measure, the convictions on game law cases to our educational program. We are predicting that in the next decade this prevention program, through education, will bring the desired results. We strive to improve our prevention program wherever we can, laying the basic groundwork for better results in the future. For example, we have in this 1953 Legislature introduced, as part of our educational program, a bill on gun safety for minors. Under this proposed bill, the minors would have to pass a gun safety examination and exhibit a certificate that they had passed such examination before obtaining a hunting license in this state. It is our intention, if this bill becomes law, not only to teach them gun safety, but outline to them the conservation story at the same time. Such efforts as these convince the public that enforcement officers are attempting to prevent violations by practical application. Therefore, in the interest of improved law enforcement, it is recognized that conservation education must be considered on a state and national basis.

Nothing can long endure, our wildlife, our soils, our forests, or our democracy, unless we build up in those who follow a consciousness and a conviction that these heritages must not be abused. Unless a tree is fed from the bottom up, it will die from the top down.

DISCUSSION

MR. TUBBS: We have introduced the law enforcement agencies into the conservation education program, and I suspect that by sheer numbers of employees in the field that conservation officers outrank the influence that can be exerted by any other group. I might mention that as other conservation employees become more numerous, their influence will be felt likewise.

MR. L. A. GILES (New York): I would like to ask Mr. Hadland who conducts this gun safety program for the first licensee if this bill is passed?

MR. HADLAND: We have patterned this bill that we have proposed in the 1953 Legislature after your New York Law.

VOICE: May I know how the daily time of these law enforcement officers is divided and what they do from 9 o'clock in the morning until 5 o'clock in the afternoon?

MR. HADLAND: That is a good question. Our dealing with conservation law enforcement is not based on an eight-hour day. The people don't tell us that they are going to violate the law at 12 o'clock noon or 12 o'clock midnight. And so it is necessary that we be on a 24-hour call basis. The officer in the field is pretty much on his own, although we do have the state divided into different areas with a field supervisor in each area.

Nevertheless, that is why you have to hire the right kind of men and have to be so very careful that you are hiring men who are going to like to plan their own time; who are ambitious; who have initiative; and who are progressive; because if they are not that caliber of man, with the little supervision that they have, it would not work out too well.

ED. ADAMS (Kentucky): Could you tell me off-hand about what per cent of time that your conservation officers spend on youth education?

MR. HADLAND: Yes. We have a cost-accounting system in Wisconsin. We have the various activities segregated pretty well.

Now, you understand that there are certain times of the year, such as the spring and the fall when we have our heavy work load. So the summer and winter is when we spend most of our time meeting with Boy Scouts and youth organizations in the summer camps; and in the winter we go to the schools.

Now, we have not gone to every school in Wisconsin. I don't want to leave that impression. But we did make 43 schools in the northern part of Wisconsin, which is one-fifth of the state. And this year we covered the rest of the schools that we missed there last year.

And this past winter we started in in another part of Wisconsin, where there was really a lot of violating going on, and we felt that we had hit the hot spots first. But our experiences are that we will probably cover the whole state as we can.

VOICE: Does the conservation officer segregate the time spent on conservation education in his report from that spent on enforcement?

MR. HADLAND: Yes, although the two in my opinion are right together.

You can think of enforcement as just being out here waiting for some fellow to violate the law. But I think of good enforcement as preventing it before he violates the law, because you, nor I, cannot blow life back into deer that have been illegally killed. And if we can prevent the person from shooting the animal or taking the fish illegally, then I think we are truly on the right track.

MR. WILLIAMS: I would like to ask how many officers you have in Wisconsin, and are they assigned a specific territory, and what is their pay scale?

MR. HADLAND: We have 105 officers in Wisconsin to cover 56,000 plus square miles. And when you think of a town maybe of 25,000 to 50,000, and they have, I don't know how many policemen; and then you think of a warden who is assigned generally to a whole county, with 71 counties in the state, you can appreciate the magnitude of the job.

If there is only one warden in a county, he is assigned to that county for administrative purposes. But that does not mean, when he comes to the county line, that there is a barrier there. He is a state officer. Some of you fellows who have had to do with law enforcement in years back used to think, "This is my bailiwick, and don't anybody else come in, because this is mine." But that condition does not prevail any more, except as it relates to the administrative end of it.

Now, in regard to salaries, we have a one, two, three, four and five classification in the conservation development division. The one is the recruit; and he starts in as of the present time at $205 per month plus $65 per month cost-of-living bonus, plus 10 per cent of his back salary, which is the $205, which would give you $20.50 that you would have to add on for taking care of this guy who violates at 2 o'clock in the morning, if you understand what I mean.

VOICE: Does your game warden have authority to arrest other than for violation of game laws?

MR. HADLAND: No. His enforcement duties are restricted by the conservation laws generally. However, he does assist and has in many many cases where there have been burglaries, where there have been stolen automobiles and when general help is needed by the sheriff. And the police officer the same way. And I might add that Wisconsin's law provides that all sheriffs, deputy sheriffs, policemen, and constables are *ex officio* conservation workers.

CHAIRMAN SHOMON: We have another very fine treat in store for you. I am very happy to see a good sprinkling of ladies here this morning. God bless the ladies. If it were not for their wonderful help in conservation, we would probably be a lot further behind in our work than we are. In my own state, why, they have been very instrumental in getting through a lot of fine constructive legislation.

We have with us this morning a lady professor. She is assistant professor of geology and director of conservation education at the Alabama State Teachers College for Women, Montevallo, Alabama, Miss Ethel Marshall, who will speak on the influence of women's organizations in conservation education. And I am sure it is a very important influence in conservation education.

THE INFLUENCE OF WOMEN'S ORGANIZATIONS ON CONSERVATION EDUCATION

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PURPOSE

The purpose of this discussion is to show the important position of women's organizations in the movement to establish the teaching of conservation concepts and principles as a vital part of the school curriculum. Women, as well as men, have become aware of the acute need for challenging youth with the opportunity of renewing many valuable resources and of developing a wiser use for all natural resources, renewable and non-renewable, if we are to look forward to a future with a sound economic system.

The activities and influences recorded in this paper will be largely those of the General Federation of Women's Club and the Federation of Garden Clubs of America. The speaker does not claim to have exhausted all sources of information but she has made fairly broad investigation. Some organizations, such as the Business and Professional Women's Clubs have, at present, conservation committees to ascertain what the organization might undertake and to make recommendations accordingly. Other groups such as the Daughters of the American Revolution, the Home Demonstration Clubs, and Parent Teacher Associations are represented in the various projects discussed in this paper, even though conservation does not seem to be a major phase of their activities. The term "women's clubs" will be used hereinafter as the designation for any women's organization which has had an influence on conservation education.

EDUCATION OF MEMBERS THROUGH STUDY

Women's organizations have been in the vanguard in every important issue in this great nation of ours for many years. The General Federation of Women's Clubs, in 1896, at their national convention under the leadership of their second president, Mrs. Ellen M. Henrotin, passed their first conservation resolution. In this resolution they pledged themselves "to take up the study of forest conditions and resources, and to further the highest interests of our several states in that respect."[1] Since then they have expanded their goals to include elaborate programs of study which acquaint their members with a broader knowledge of conservation and resource problems. This has resulted in many projects of inestimable value throughout this nation. In their study of conservation they have included, in addition to the more formal lectures and discussions, many "show-me" trips. These trips, on which thousands of women have actually seen examples of misuse as well as the wise use of resources, have been of tremendous value. With this background of information women have contributed toward the development by many citizens of a better understanding of wiser natural resource utilization.

EDUCATION OF MEMBERS THROUGH PROJECTS

This study has led to projects in which actual conservation principles have been applied to restore a diminishing renewable resource. One excellent example is the Range Reseeding Project in Carson National Park in New Mexico. Within a few months 2 000 women in 36 clubs secured the money to plant 33 acres of barren land to intermediate wheat grass, prepared a marker for this plot of land, and agreed that they would support the project for 25 years. The seed from this plot will be harvested and used to reseed other New Mexican range

[1]The information for this paper was gathered from files of the Conservation Chairman of the General Federation of Women's Clubs, the Garden Clubs of America, and the Daughters of the American Revolution, as well as from correspondence and questionnaires. Therefore, no further bibliographic note will be made to the above sources.

land by the Forest Service under the provisions of the Anderson-Mansfield Act. Another example is the reforestation project sponsored and planted at Flagstaff, Arizona, by the Alpine Garden Club. This once-burned area located on a main highway is now used as an excellent reforestation public demonstration plot in an area that depends largely on trees and tourists for its livelihood.

Conservation legislation is another field in which women have participated. The women's organizations in several states have supported legislation requiring that conservation be taught in the schools. There are few if any examples of such legislation improving the teaching of conservation. If school administrators are not aware of the need for its inclusion in the curriculum and teachers are not trained in this field, no purpose is served. If school personnel is aware of the need and is trained, legislation is unnecessary to insure its being properly taught in the school. Therefore it is the opinion of the speaker that instead of pushing for curriculum legislation, a more rapid achievement in conservation education will be made by men's and women's groups that will continue first, their efforts to inform the public, whose opinion is a power in any community, and second, to encourage and assist educators in the training of young people. However, much sound and constructive legislation in conservation has been supported by women's groups. The Anderson-Mansfield Act mentioned earlier was one which had the support of the General Federation of Women's Clubs. Its basic principles had been approved by them for some time prior to its passage. Other legislation pertaining to natural resource development and scenic preservation has been passed with the approval and assistance of women's clubs.

CONSERVATION EDUCATION

Conservation having become such a major phase of study and work for many women's clubs, it is not surprising that they should be concerned with conservation education in the schools. Again they demonstrated a wise approach to the problem of making conservation education a vital part of the school curriculum. They planned the steps to achieve their goal in a logical sequence: The first step was to secure teacher training courses; the second, to provide scholarships for teachers; the third, to include conservation education in the school program; and the fourth, to assist the schools and the youth in practical and specific projects.

Workshop. They were aware that there was little use to agitate for a vigorous conservation program in the schools until teachers were trained in this long-neglected field. They urged and encouraged many higher institutions to offer courses in the summer school sessions.

While in many states Conservation or Resource-Use Workshops were the cooperative result of the efforts of educators, resource specialists, and an interested citizenry, in several states the women's organizations have been a real force in establishing these training centers for teachers which are now a source of pride to the home institutions. While several men's and women's organizations have supported the Resource-Use Workshop at Alabama College, the continuous cooperation of the Federated Women's Clubs throughout its nine-year history has been most gratifying.

Scholarships. These women realized that teachers should be encouraged to take advantage of such teacher training courses, so they offered scholarships. Thus, many good teachers honored with scholarships were encouraged to secure special training in conservation education. When this project first began it was most significant since it enabled so many teachers in the lower salary groups to return to college for at least a summer course. These scholarships are necessary today in some states, where salaries are still low, and where only a small percentage of teachers have acquired this training. The women's clubs in Pennsylvania, Alabama, Arizona and New Mexico offered scholarships for teachers to attend summer courses in conservation which totaled more than $3,500 last summer. Figures were not secured from clubs in other states. The County Club federations in Michigan sponsored four teacher training workshops in 1951 with an attendance of 250 teachers.

The women's clubs have observed these workshops in operation by accepting invitations for short visits, even under difficult conditions. One group of five women made the 125-mile trip from Tucson to Tempe, Arizona, in 120° weather last summer to attend sessions of a workshop to which they had sent teachers.

Curriculum changes. Curriculum changes to include conservation education in public schools have been encouraged by women's organizations. In a western city a general conservation workshop for club women led to the promotion of conservation in the schools of that city. A school administrator and two teachers who were present admitted that they were impressed for the first time with some major local resource problems and realized that the young people could have a vital part in their solution. Los Angeles plans are moving forward to set up a pilot school in a public school system for resource education. Several women's clubs have cooperated with the Conservation Department and the Board of Education in launching this project of a pilot school.

In a southern city the grounds of a new school needed landscaping and planting. A Garden Club was impatient with the delay in the landscaping. The conservation chairman of this club invited the teachers of the school to a specially planned meeting, and secured pamphlets, charts, and posters on a variety of resource topics for the teachers. The teachers were made aware of some local resource problems and began to work with their children on these problems. Within a short time the children in the fifth and sixth grades were particularly interested, and other resource studies were begun. Now a school, in which the majority of teachers, children, and patrons thought that conservation was a subject about which only the farmer could do anything, has properly integrated the subject into the school curriculum. In addition, there is a six-weeks project for the four sections in the fifth and sixth grades in a different phase of conservation each year leading to a resource or conservation activity. This spring the culminating activity is the planting of 100 fast-growing elms as a fence row to separate school and residential property. The students will plant the trees, supplied by the Garden Club, under guidance of trained foresters. While the value of a set pattern of six weeks' study at a certain time each year is questionable from the viewpoint of a trained educator, that community has become conservation minded.

In a midwestern county a conservation chairman invited a supervisor of rural schools, who was "lukewarm" to conservation education and who thought she was doing all she could, to speak on the same club program with a supervisor from an adjoining county who was doing an excellent work with her teachers. Thes are examples of the shrewdness of women in changing the school curriculum.

Specific school projects. The number of specific conservation education projects which women's organizations have sponsored with schools is almost endless. These include such things as: (1) fire control and reforestation projects in schools, (2) contests of various kinds in conservation, (3) conservation camping, (4) Girl and Boy Scout training, (5) assisting in field trips for high school classes by providing cars for transportation, (6) bird house projects, (7) radio programs, and (8) planting roadside parks, rose gardens, and vegetable gardens. While each of these projects has been used as a means of teaching conservation, only the first four will be discussed, and these briefly.

a. Fire Control and Reforestation.

That fire control and reforestation have been more widely demonstrated than any other aspect of conservation can be readily assumed from all records. Some of these have been most effective. In Idaho there is one Youth Forest in each club district, sponsored by the district, concerned with the education of youth in the conservation and wise use of Idaho's forests. Nevada has begun the same project with two Youth Forests this year. In Montana in 1948 the Coran School students at their annual picnic planted 2,000 ponderosa pine seedlings furnished by the women's clubs. In Pennsylvania in 1947 a women's club sponsored, in cooperation with a school, the planting of 700 trees and berried shrubs in a bird sanctuary and forest preserve. These women raised and spent $700.00 in 1947, $500.00 in 1948, and $300.00 in 1949, with annual plantings to be continued. This is an excellent laboratory for this high school biology department. In Michigan, a school-community forest of 280 acres, in which all community organizations have cooperated, has been a laboratory for a number of years for such high school departments as science, biology, literature, mathematics, health and safety, and social science. In Alabama the Forest Dale garden club pointed out the barren and vacant school land owned by schools in the community, and in the first year, six schools planted 13,000 pine seedlings. That was four years ago. To date, those six schools have planted 26 000 seedlings. One encouraging result of this project is that in that community, in what was known as the "hottest" fire patrol area in the state with incendiarism as a major cause of fires, and where 2,000 of those seedlings were planted the first year, the following fire season there was a *75 per cent reduction in the fires* in that area. In each of the few fires that did occur, there were 50 to 75 enraged boys and girls ready to help fight the fires. The change in the attitude of the citizens of that community is unbelievable and it is emerging from an unsightly spot to a beautiful one.

b. Contests.

The contests sponsored for schools have been as varied as the problems in conservation. There are many essay contests with subjects ranging from such broad topics as "Protect Animals, Birds, and Wildlife" to more specific ones, such as "Clean Waters for Our Town." Clubs in Minnesota and Illinois have added the interesting phase to their contests of sending the group of winners for a week's vacation and training in a conservation camp. Among the more novel contests is that of the extempore speeches on conservation subjects, one of the first having been sponsored by clubs for Utah's high schools. Another new one is the Ready Writing contest sponsored by an Alabama Garden Club, in which the students, after a period of study, are given a list of topics from which they write an essay in class. North Carolina Clubs have sponsored poster contests which have encouraged the art students to become interested in conservation.

c. Conservation Camps

Conservation camps are growing rapidly, and women's organizations have not been lagging behind in this field either. Only a few examples of their cooperation in camping will be presented here. In Illinois, the sportsmen's clubs and the Izaak Walton Leagues sent 50 boys to the Conservation Training School of Lake Villa for one week each. The women's clubs soon observed the weakness in this program, and now they provide scholarships for 50 girls. The Virginia clubs operate the Nature Study Camp in which approximately sixty youths attended in 1951, and the Wisconsin clubs sent 300 high school students to Trees for Tomorrow Camp at Eagle River in 1951.

d. Girl Scouts and Boy Scouts

In several states garden clubs have sponsored conservation projects for Girl Scout Troops. In one troop the work on the Tree Badge has led to a conservation project that is attracting community-wide interest. The state conservation chairman for the Garden Clubs of Alabama, with a Boy Scout leader, has worked out an achievement award in conservation for Boy Scouts. It has been approved at the state level, and the details are now being worked out to be sent for national approval. This type of assistance in youth organizations can be of tremendous value in challenging and training young people in conservation.

Conclusions

In conclusion, the women's organizations have demonstrated a deep sincerity of purpose in their quest for knowledge of resources, not only to rectify an unwise use of resources, but in their efforts to secure education in conservation for the boys and girls of this nation. The range of activities of the women's organizations is a broad one, and the specific projects are numerous.

Their contributions in encouraging and supporting teacher training courses in conservation cannot be measured, but as a result of their efforts over a period of years—as many as ten in some few states—there is now over this nation a nucleus of teachers trained in conservation. It is the observation of the speaker that a teacher effectively trained in conservation education does a successively better job each year. Therefore it would be impossible for these groups to secure a higher interest rate on their investment.

They have shown cleverness and diplomacy in urging for curriculum changes and have often accomplished their purpose with no harm but richer school programs as a result. Some criticism has been leveled at the men's and women's organizations for attempting to dominate a school curriculum by legislation or public pressure. The speaker agrees that trained educators should determine the curriculum, but surely the public should be alert enough to know what is being taught and what is not. Citizens do have a responsibility to urge the consideration of a neglected area of knowledge, and this is far different than regulating the curriculum by law. There would be no need for such legislation if school leaders had been made aware of the urgent need for conservation education.

The numerous projects which give students a practical opportunity to study local resource problems and to apply conservation concepts and principles have had many valuable results. Some of them would have been impossible without the knowledge and leadership of club women as well as their physical and financial help. However, when projects are an integral part of the regular class work, the learning situation is much more effective. Then it is that the student, under the guidance of a trained educator, can view the situation, learn to recognize the problem, and assist in the solution. This problem-solving attitude toward conservation is the only effective means of solution. It is a happy situation when ingenuity is used in planning for school projects such as the poster, extempore speeches, and the Ready Writing contests. Some of the projects which have been successful from an educational standpoint have been these in which there was close cooperation at the planning stage between the teacher and the club women.

The encouragement and assistance given to camping in which the programs are centered around conservation can be and has been a stimulating experience for young people. The speaker is hopefully expecting that women's organizations will soon be found in the new movement for conservation camps as a part of the regular school program. The work with youth in the Girl Scout and Boy Scout organizations is another means of assuring that a new generation is being educated in conservation, Certainly in the near future the women can point with pride to the Boy Scout achievement badge in conservation, since it was the brain-child of one of their number.

Finally. then, it can be said that the influence of the women's organizations has been significant. These organizations have made a valuable contribution in arousing educational leaders as well as lay citizens to an important part of our youth in the wise utilization and preservation of those resources on which our civilization must depend. It is hoped that the women's organizations will continue as they resolved in 1896 to study resource conditions and "to further the highest interests of the several states in that respect."

DISCUSSION

MR. TUBBS: Miss Marshall certainly gave good testimony for the women. I have had the opportunity of working with a good many women's organizations in this field, and it is obvious that women get more fundamental about these things much more rapidly than the men's organizations. However, the men usually get around to the point sooner or later.

But nevertheless the women are, I think, very unselfish in their attempts to get right at the problem and attack at the point where it should be handled.

CONSERVATION EDUCATION WORKSHOPS—A MEANS TO BETTER RESOURCE USE

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While assisting classroom teachers and supervisors and serving over 30 conservation education workshops during the past two years, the writer has become alarmed at the apathy and lack of knowledge teachers have regarding community resources. The writer has found few teachers who can identify the major industry and common natural resources of their home town or the place in which they are teaching. Further questioning by the writer has indicated that those teachers who can identify their town's major industry and source of income usually do not know what raw materials are vital to the industry. It is the rare teacher who knows the source of the raw materials.

How can teachers and other citizens who are unfamiliar with community resources and problems of local resource use comprehend state, national, and international conservation problems? How can such teachers give students guidance that will help make the youngsters stewards of their nation's resources?

Basically, resource-use problems are the same the world over. The teacher who is familiar with the common resources of her own community and has an appreciation for the need and methods of managing these resources can comprehend basic conservation problems in her state, nation, and other countries.

Most of the weaknesses in conservation education in American schools today can be traced directly to the inadequate preservice training of the classroom teacher. It would be safe to generalize that the vast majority of teachers who are attempting to initiate a unit in conservation are victims of poor science teaching.

A child is instinctively curious about the "things" in nature surrounding him. He examines with his eyes and fingers; later he may utilize his sense of smell and taste in getting acquainted with an object that interests him. Unless the child's curiosity in nature is further stimulated, and the child is shown at all levels of understanding throughout his growth the ways and basic needs of living things and his dependency upon plants and animals, he will not receive the broad basic concept of his natural environment necessary for a working knowledge for wise resource use.

The elementary natural science training of today's teacher—and too often her pupils—consisted mainly of learning the names of objects and identifying them. Little thought is given to life histories, interrelationships, and simple ecology. Pity this poor student when she went to college. There she studied the anatomy of the animal or plant and probably handled, for the most part, dried or pickled specimens. How can the teacher appreciate the importance of the frog in the ecology of fish and mammals if she has merely been acquainted with the frog's name and anatomy? Every effort must be made to present biological concepts in a functional manner so the prospective teacher will be able to apply this information to community problems.

Courses in conservation education and especially courses which provide opportunities for fieldwork, and first-hand study of community-use problems, are proving helpful to prospective teachers whose science training has proven factual but not functional. The needs of living things become apparent, and man's future is seen to rest upon his use of renewable and nonrenewable resources both natural and human.

The majority of our classroom teachers and school administrators as undergraduates had no opportunity to profit from direct and indirect learning experiences in the conservation of natural resources either in an integrated curriculum or by the course approach. A background in basic conservation education should be required of every prospective teacher. As the colleges of our nation add and strengthen conservation instruction and obtain instructors with thorough preparation in conservation education, future teachers will be better able to give our citizens of tomorrow an appreciation of local flora and fauna and the conservation of basic natural resources.

Some of the principal means by which the preservice and inservice training of teachers can be strengthened are as follows:

1. Enriched courses in biology and general science provide functional experiences with plant and animal life and show life histories and ecology. It is useless to cram preservice and inservice teachers with details of anatomy, physiology, and taxonomy—all highly important to the professional biologist but of little use to the classroom teacher.

2. Courses such as field natural history and outdoor laboratories give teachers experiences with living things in her environment. The teacher is better able to utilize the schoolyard as an outdoor laboratory.

3. The preparation of conservation literature and audio-visual aids designed for specific grade levels and areas of study.

4. Conducting conservation education workshops to help inservice teachers whose contact with conservation education has been limited.

The writer shall emphasize the use of the workshop technique though it is by no means *the* answer to better conservation education.

A workshop has been defined as a group of people working together democratically toward the solution of problems of mutual concern. Conservation or resource-use workshops usually concern human and social resources as well as natural resources. Properly directed, the workshop is one of the most effective methods of teaching. The participants in a workshop are freed and encouraged to participate actively in this method of learning. Members identify and define problems drawn from their own experiences. The staff is selected to serve the purposes of the workshop and to make maximum use of all resources available. The staff does not teach a course. Rather, the staff assists the members of the workshop toward the solution of individual and group problems. The members of the workshop cooperate in planning, organizing, conducting, and evaluating. Thus workshop participants have opportunity to develop skills in the group process of learning which will help in working with school and civic enterprises.

A typical daily workshop schedule will include time for a general session, large-group meetings, work periods for special interests, meals, and relaxation and recreation. Evening sessions may be held if such sessions are found desirable and are needed.

Many study techniques are applicable to a workshop. The members need to analyze the various techniques and use those that are most applicable to the various groups and individual needs. Techniques that have been found helpful include discussions, group discussions, symposiums, lecture-discussions, sociodramas or role-playing, interviews, surveys, first-hand observations and experiences, field trips, observations of good teaching, demonstrations, use of audio-visual aids, assigned reading, recording and reporting, action projects, and individual projects for work to be carried out back home.

State and federal conservation agencies and colleges and universities working as a team in meeting the everyday needs of the classroom teacher are doing much to strengthen conservation education. Colleges need the help of professional wildlife technicians, foresters, soil and water technicians, and other resource personnel who can speak the language of the classroom teacher and understand her problems.

In Texas, the coordinator of resource-use education, a member of the staff of Texas Education Agency, contacts colleges and universities seeking resource consultants from such state and federal agencies as the Soil Conservation Service, Texas Forest Service, Texas Game and Fish Commission, State Board of Health, and Department of Public Safety. Representatives of the oil and gas industry also cooperate. Dates suggested by agency representatives at a previous planning conference are presented to each college, and the college notifies the coordinator if the dates and consultants are satisfactory. The college contacts the consultant and supplies him with information pertinent to the workshop and the consultant's objectives.

There are dangers in the use of consultants. Too often the consultant or resource person merely serves as a visiting lecturer or "visiting fireman," answers a few questions, and departs. Seldom is the consultant supplied with sufficient information regarding the objectives of the workshop and what will precede and follow his visit. Generally the consultant only has two or four hours before the group and must spend this time orientating the group about his particular resource. There is seldom time for the consultant to work with individual students or student committees seeking information for units or curriculum planning. The participants in the workshop must be prepared for the consultant's visit and should already be oriented regarding the agency its purpose, and scope of activities. Each participant can also be provided with a packet of teaching aids distributed by the agency before its representative's arrival so the literature will be familiar and the consultant can devote more time to its use by the classroom teacher.

Wherever possible, resource consultants in Texas are giving priority to those workshops that are well organized and better able to use the consultant's services effectively. If there are open dates on a consultant's itinerary, an attempt is made to visit as many colleges as possible along the route of travel that have requested consultant services for one or two days. The workshop and the agency supplying the services of the consultant will find it most profitable if the consultant can work full time with the workshop.

In the last analysis, the success of the workshop is determined by the improvements it makes to the participant's teaching. A student should leave the workshop with an action plan ready for use. Such an action program may consist of units of study, plans for special class or school projects, and action plans for the school or community. Plans for such projects must come within the scope of the workshop and fit local conditions in which the plans are to be used.

The Committee on Southern Regional Studies and Education, in its excellent booklet, *Guide for Resource-Use Education Workshops,* suggests consideration of the following activities:

1. How to implement plans for resource-use education in local schools and communities.
2. How to arrange periodic visits by staff, consultants, and others to see what problems have been encountered and to assist participants in carrying out plans made in the workshop.

3. How to exchange information between participants about what is being done in the local situations.
4. How to obtain periodic reporting by participants through newspapers and educational periodicals on projects initiated.
5. How to adapt and use workshop techniques, as means of developing better cooperative relationships with the community agencies.
6. How to use materials and plans produced by the workshop for:
   (a) Planning additional workshops dealing with other phases of resource-use education.
   (b) Discussing and working on resource-use problems in the local school and community.
   (c) Stimulating a wider interest in, and a broader understanding of, the concepts of resource-use education.
7. How to use workshop participants as consultants in other workshops.

It should be kept in mind that the workshop is an educational device for mature and experienced persons. A properly conducted workshop will prove to be a most worth-while educational experience to the conscientious student able and ready to contribute.

CONCLUSION

The increasing use of the workshop as an educational device in conservation education demands the attention of conservation education officials.

While participating in conservation workshop activities, teachers become better acquainted with local resources and resource-use problems. Human resources, natural resources, and social resources are considered, and the members of the workshop work out problems of resource use drawn from their own experiences.

At workshops mature and experienced teachers analyze specific conservation problems and develop plans for their solution. An action plan is prepared that is applicable to the teacher's community.

Few in-service teachers have had training in resource-use education. Functional science experiences, including field training in nature study, ecology, and resource-use are required to furnish basic information to the workshop participant.

The workshop is an excellent place to work out teaching methods, lesson plans, and visual aids that will awaken the interest of youth to conservation problems and the fascinating animals and plants of the school community.

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DISCUSSION

MR. TUBBS: Certainly I think that the local resources are the things the teachers can use best in their instructional work. Now, those are some of the things I think that are well worth considering just as a point in itself.

Are there any comments or questions regarding Doctor Weaver's paper?

MR. MAURICE BROOKS (West Virginia): I believe one of the greatest by-products of conservation workshops we sometimes fail to realize. That is that it gives in-service teachers training in teaching through field-trip methods. The average school offers nothing to the teacher who wants to teach biology outdoors where living things are. And the teacher who goes through a rich experience in a conservation workshop learns something of the techniques of teaching out of doors. I think that is extremely important as a by-product and a major product of a conservation workshop.

MR. TUBBS: Someone has summed that up by saying "teaching the teachers to live dangerously." Are there other comments or questions?

MISS MARSHALL: I would like to ask if any of the institutions in Texas that are operating these workshops have made any attempts to secure reports from these teachers over any period of time. I think that there are some possible future advantages in the reports, not just in checking up on the teachers, but in getting a picture of what teachers actually are doing. I also found them a means of encouraging teachers to do still more.

DOCTOR WEAVER: Yes. The Texas Forest Service and the other agencies—particularly the Texas Game and Fish Commission—are inviting teachers to prepare units, and we are often publishing those units and distributing them to each teacher. The Texas Education Agency right now has said, "Prepare units; we will publish them." The state educational agency is doing it. This has not been brought up this morning, but, as you in conservation departments prepare literature for teachers, please get teachers to help you in preparing those publications and in writing them, because many of us are not educators. We have not had the classroom teaching experience. And there is no one better than the teacher who can see what is needed along a certain line in this publication.

If you are going to prepare a publication for the second or third grade or a certain grade, get teachers with wide experience in that grade level to assist you, and your publication will be used, and I do mean used.

CHAIRMAN SHOMON: Thank you, Doctor Weaver, Mr. Tubbs, for participating at this very fine session this morning. I wish to thank the rest of the panel members on behalf of the Institute for their very valuable time, for their hard work in coming to us this morning, to participate in this discussion and in a very fine presentation. I also want to tell you that you have been a wonderful audience. You have stayed right with us. And it is a pleasure for all of us on the panel here to discuss these problems of conservation education with you when the interest is so great.

NATURAL RESOURCES AND HUMAN NEEDS

Appraisal of the 18th North American Wildlife Conference

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Ladies and gentlemen, I should like first of all to say a word of appreciation for those who are privileged to attend this conference. We know the immense effort that has been required from the Wildlife Management Institute, the Program Committee, The Wildlife Society, the hotel staff, and others who have made this meeting possible. Those of us who come from far away, particularly those from outside the United States, rejoice in the opportunity to visit Washington, which so truly and faithfully looks and plays the part of capital of a great country. We notice the absence of the usual civic greetings; we realize that it is uncalled for and unnecessary because Washington belongs to all of you.

Washington is so important to the people who make up these Conferences that we drift back here every few years. After all, the first one on this scale was called by the President, back in 1936. Fortunately the conservation movement had in its ranks non-governmental people who were able to take on the Conference, but things both big and little that are ordered here, by Administration and Congress, can boost the conservation of natural resources ahead, or set it back on its heels. Even as we met there were several hearings called which were of great importance to conservation in this country. The free discussions of this and past Conferences show that there have been both boosts and jolts. It is not chance that brings us here this year.

Under these circumstances it is very much worth while to have the program reiterate some of the lessons we have learned. We have had moving about among us some two hundred Congressmen, who, presumably, want to know who we are and what we stand for. Their interest is encouraging. Equally encouraging, however, has been to have the old lessons of conservation repeated by new men; for instance in our opening session by the Secretary of the Interior, and later by the Directors of the Forest Service and the Soil Conservation Service.

May we permit ourselves to hope that there is now a present generation of legislators who know what natural resources mean and realize that something must be done to manage them, and back of them a public that is more wide awake than we dared to think. When the Secretary of the Interior said that he wishes that his responsibilities were only for the things you are concerned with, you can be sure he had no misgivings about public support.

As appraiser, I wish particularly to mention those who helped me. Thanks to our tireless and self-effacing friend Jim Trefethen, and to the various chairmen, I might conceivably have written an acceptable summary before I even came here.

The Conference is an event of such importance to conservation that it has become a very great privilege to be allowed to help with the program. I say this for speakers, discussion leaders and chairmen because I know that in a few minutes "Pink" Gutermuth will likely be on his feet thanking all and sundry. It is a particularly high honor to be asked to act as appraiser, and I appreciate it deeply. It has done something for me. I confess that I was formerly a confirmed corridor haunter, either one of a group in earnest conversation in the middle of a passage-way, or loitering alone, the degree of anxiety expressed being proportional to the supposed urgency of picking out a name on one of the tags that go flashing by. You know the old excuse—it is all going to be printed anyway, and it is the bull sessions that are really valuable. After three days of diligent attending at lectures I can truthfully report that I met and talked to more people than ever before.

It has indeed been a great Conference, worthy of those memorable Conferences that have gone before. There were, in other years, some memorable appraisals, too. At one time I dared to hope that this might be another, but as my brain became gradually numb my hope dwindled, and in its place there grew a more profound respect for those who in the same predicament have managed to think up something worthy of the occasion.

Looking over their words I see that the summarizer's apology is as inescapable as the whereas in a resolution. The great drawback is that one's thoughts are carried along a course determined by the impact of one speech after another. My emotions are my own, and so is my particular brand of ignorance. I am afraid that both may be so different from the majority of you that I may fail utterly to reflect the light that dazzled you. Also, the line of thought generated in the meetings may lead me right past the one paper in the Conference that will put a premium on the Transactions. May I add that there is nothing in this appraisal not inspired by the program. If I mention a name or a paper it is purely a matter of rhetorical convenience. Most of it has a multiple inspiration which precludes acknowledgments.

Natural resources are our great preoccupation, and their conservation is no less urgent to this group than to those of other years. We have realized for some time that our resources are like a bank, a bank on which all our cheques are drawn, and heaven help us if they ever start to bounce! The next stage was the realization that resources are interrelated—in other words there is really one big bank and not a number of small ones. The next and, in some ways, most alarming revelation was that we and our resources suffer when resources are depleted in other continents, which means that the level of our assets is connected with that of other banks, whether we like it or not. The Iron Curtain makes things worse by diverting goods and services into the uses of war, so that, figuratively if not literally, resources go up in smoke. These things we must reiterate year after year.

Human needs, whose relation to resources we are supposed to be considering this year, while they have received some mention, have scarcely been dealt with in general terms, but I should like to insist that they too are one whole, and not a collection of separate pieces. Many human needs are in part measurable, such as calories, cubic feet of air, gallons of water, and traces of rare elements. Other needs are not capable of measurement, such as elbow room, privacy, scope for the imagination, answers to the questions that bother us, play, competition, congenial fellowship, and a sense of accomplishment. They are just as important, and the manner in which the unmeasurable and imponderable needs are met affects the measurements of the measurable. How much food a man can get by on, and how well a man assimilates the food he gets may depend on how happy he is. We live by bread, but, as the Bible says, not by bread alone.

I used to be a laboratory man, and, if I may, I should like to describe two lots of guinea pigs—real ones—I used to know. One was kept in brand new quarters, where it was plain that a great deal of ingenuity had been used to keep everything as sterile as possible. The animals were in racks on wire so that excrement and bits of food all dropped into trays which could be sterlized as often as one wanted. Food and water were so dispensed that the animals couldn't mess around with them. The only smell was phenol. The beasts were puny and lousy, and if you wanted to be sure of results you had to use plenty of them because some were sure to die. The other lot was kept by a mellow old biologist whose work and outlook always bore the stamp of originality and understanding of animals. They were on the floor of an old barn, far from sterile, and they had enough straw to hide in. The place smelled guinea-piggy. His pigs were big and fat, free from lice, and when they were used in an experiment they did not go off and get sick on their own bat. I mentioned the other lot to the old man and he snorted scornfully, "They think they can treat an animal like a test-tube. My pigs are better than theirs because mine are happy and theirs are not."

Comparisons are trite and odious, but still, I ask, do we think we are any different? This kind of need is what we are trying to meet. We feel that the extent to which it continues to be met on this continent will set the limits to our greatness. We know our job is important, but sometimes we are baffled when we have to stack intangible values against dollars, calories, acre-feet and what not.

Aldo Leopold, who used to squelch our platitudes and force us to face our facts, evidently made a clear distinction between wants and needs. At one Conference he said, "What we call economic laws are merely the impact of our changing wants on the land which supplies them. When that impact becomes destructive of our own tenure in the land, as is so conspicuously the case today, then the thing to examine is the validity of the wants themselves." That is to say, we should determine which wants are really needs.

It is not my job to present an essay on human needs. I do think that we are here because people want to feel that what we are doing to our resources is right, and they have grave misgivings, also that it is very necessary that what we do should be right.

Our people want nothing better than to be unreservedly proud of the great industrial civilization that we have built up. The only real cause for misgiving is our handling of renewable resources. The very advertisements that depict the fortunate owner of a modern automobile hunting or fishing far, far, from home, needle the sore. Once you could fish and swim at home. Soon there will be no more hinterland. We feel upon us the condemnation of the prophet Ezekiel, "Ye have drunk of the deep waters and ye have fouled them with your feet." That terrible judgment is for more than mere carelessness. Respect for the Creator and consideration for the other fellow, together, as we were once told, are the essence of the whole Ten Commandments. Filthy and unproductive waters and empty fields and forests are the negation of all that we have been taught to cherish in the inner temples of the mind. You American's sometimes sing "I love thy rocks and rills, Thy woods and templed hills;" but rill is fast changing its meaning by its association with erosion. Most of you also learned in childhood about a promised land flowing with milk and honey and you may even have sung a song about it.

By cool Siloam's shady rill
How sweet the lily grows!

The grim reality of today is the shattering of a dream. People are like the lands they live on. You remember how the poet Goethe, who was a biologist in his own right, exalted by the beauty and majesty of the art and literature of Greece and Rome, wrote a glorious song "Knowest thou the land?" I once read that old Roman naturalist, Pliny's, description of Italy's woods and templed hills to a veteran of the war in Italy, to be greeted by incredulous laughter at first, followed by amazement that land could be so changed. If our children are to be happy we have two alternatives, either to stop singing such songs and instead prepare them to accept the kind of future they are going to get, or to do something about the management of renewable resources and prepare for them the kind of future we think they ought to have. Why do I speak in this vein, when Dr. Mills did last year and others before him in other Conferences? Because we must remember these things and we are so comfortable that it is easy to forget!

Somehow we must strive to give husbandry a place in the esteem of our culture equal to horse power. Neither of these concepts was originally tailored for the atomic age, but if the one can survive, then surely the other must also. By husbandry I mean, as much as anything, the continuance of life on every last square inch of our land and the enriching of as many square inches as possible. Think of the Scandinavian and Swiss hill farms, where originally nothing was arable, where stones have been lifted and earth transported by hand until fields and pastures have been made, and where it has been the pride of each generation to add something, be it ever so little. Or think of the English squire of the anonymous poem, who planted covers for a game harvest that would come only after he was gone, and prayed that his son would hold his lands in trust and pass them on in his turn to loving hands.

There is so far nothing very ancient here about the things that we have made, though we have destroyed the forest primeval and the top soil, if not the rock, of ages. However, field, forest or house can be built to last if we bestow our respect where there is obvious sign of permanence. When we can apply to our continent the formula once used in selling farm lands, "The whole in good heart," then we can sit back and take it easy.

Our general sessions have been both healthy and helpful. This year's opening session was captioned, "Populations vs. a Resource Budget." We never did get these terms defined. I suspected that a resource budget would turn out to be something that flashed a green light for schemes to manage renewable resources. Nobody seemed willing to say so. When the word "populations," which for the purposes of that session surely meant just "people," was used in antithesis, I wondered where the people came into the picture as denying money for resource management. Was it their increase year after year, or was it the competition in budgeting from welfare services and social security schemes? We know, as I have said, that the cheque is no good without the bank, whether it is drawn for a welfare scheme or just to feed some more mouths. The pitch was certainly not called to make it easy for the batters, but none of them was fooled into suggesting that people could do without a resource budget.

It was the picture of population increase and its implications that was presented to us. There is no question that we are going to have many more people, the only question is how many more. We shall have to make better use of our land, and more use, but all use is not commercial.

It is encouraging to know that there are still unexploited fisheries in the sea, enough tuna for sandwiches all round, and also that an agriculturist like Dr. Harrar can see more in the sea than fish. In the sea we have the last physical frontier on this earth. The few seemingly idle acres of wilderness left on the land have a value to us that may be more important than anything we would gain by moving in on them. One of the more interesting contributions to this meeting has been Professor Hines' philosophy of nonuse in conservation. We should be able to plan our future use of living space so as not to be stifled by our own activity. The vast open spaces of my own country are, in my belief, neither useless nor idle, just as they are now. They are part of the form in which our national character is cast.

Professional wildlifers are bound to be more skeptical, perhaps, than others of the unconventional agriculturalist's improved synthetic apple. We have seen wildlife populations do things that, thank goodness, the human race has not done yet, and we are never sure of all the factors involved. We often feel that our observations have wider implications than any we publish in our reports. We do know this—the really thriving wildlife population is one living on a healthy soil, in fact the kind of soil the organic farming faddists talk about, and living at a level well under the carrying capacity of the land.

It may be some time before we eat a synthetic super apple but it would have been easy for the Secretary of the Interior to have given us something synthetic. After all, any man who has spent his life in the political arena, with the expert help at his command, could polish up a platitude till it goes down so smoothly that we are hard put to explain just why it was unsatisfying. What you were given (remember I am a Canadian) was real nourishment, not a feast, but the promise of three square meals. When he tells you that you must meet the recreational needs of civilized living, and the development of your land must be planned and carried out accordingly, your resource budget looks reasonably safe.

It would, I think, be fair to say that when the speakers were through with that session the caption read, "Increased population demands a resource budget."

"Big Dam Foolishness" and Woodward's paper on public lands were Conference highlights partly because we all enjoy polemics. For those who don't like to see a direct attack it may be worth recalling that the Army Engineers got their licks in at San Francisco three years ago. We are sometimes confronted with a degree of urgency that requires a challenging presentation of our case. From the sidelines one may at least state a principle, that for any development that destroys as well as builds we should measure the one against the other, and, if there is any doubt, the known future value should not be sacrificed to the hypothetical, for the sake of any transient gain. Thirty million users of public lands should be eloquent advocates, when it comes to a matter of the greatest good for the largest number in the long run. One way for the people of a river valley to make sure that it gets the kind of management they want is for them to do it themselves, and not to be beholden to anybody, like the Connecticut Valley people.

Technical sessions operate more or less independently of conference themes and yet for this summary I do not find it practical to separate out the two supposedly different kinds of sessions. Technical sessions started in private rooms when the advance guard of technical men managed to get their expenses paid to the Conferences. In 1930 we had a tripartite Conference, research being one of the units. At that time Dr. A. A. Allen, who presented a "Resume of the Research Workers Round Table" and was thus the first summarizer, remarked on the growth of research and fact-finding. In those days it was well within the capacity of one man to keep track of all of the wildlife research, perhaps fisheries too, that was being done on the continent. So enormous has become its volume that I am only too painfully aware that it is no longer within the capacity of one man to keep track of all the research reported at one Conference. The big question has always been: What do we get out of it? The record of practical application is a good one so far as research reported at these Conferences is concerned. We have learned here how to approach the problem of cyclical species. We have seen the limitations of game farm stocking and fish hatcheries carefully worked out. We have learned to census our stock and estimate our production. By techniques announced here we know as much about some game populations as the insurance companies know about us. The advance of habitat improvement is recorded step by step. When we reflect on how little habitat has actually been improved, not just landscaped, it is nice to have the Transactions to fall back on because there we can see that not so long ago there was very little even to be said about it. The most obvious thing anyone following in Dr. Allen's footsteps 23 years later could say is that the technical sessions have become outstandingly practical. I should add that both the volume and quality of investigations can be related by the most casual reader of the Transactions to the rise and growth of the Federal Aid and Cooperative Unit programs. This year we have had good practical meetings though I should hesitate to call them brilliant.

Of course we are interested in hearing about sea otters, fur seals, walruses and wolverines, about game licks and beaver management in the far north, or elsewhere. The use of television to see what goes on in the water appeals to one's imagination. I personally have always thought that the reason fisheries biologists developed good sampling methods was because they couldn't see what was going on and never acquired the delusion that nature was an open book. It is good for us also to know how to deal systematically with botulism and we can hardly ignore 12 out of 12 rabbits positive for spotted fever. More about fish and their environment from the headwater stream through the estuary to the sea, more about browsing, more about fish and game harvests and the biology of various species; these are all grist to our mill.

It was high time for crippling losses in waterfowl to be studied as a single problem by scientific methods, as Bellrose and Dear are finally doing. One is pleased also to see a scientfic study of the deer-sheep relationships by a parasitologist. After Sheldon is through with the singing ground census of woodcock one shudders to hear him say that it was the basis of the shooting regulations. Quite seriously, I hope not. I also wonder how much woodcock are really affected by shooting. Fortunately techniques are improving. The day may come when we really know something about woodcock.

We even find that another hand can still strip more milk out of the Pennsylvania bounty records, from which so many statistics have been published. Latham quite frankly writes off all of the bounties as futile, but some of them might amount to something. The rest should never be considered. The plan is to eliminate bounty payments on predators that would have been killed anyway, and spend the money on evoking the extra effort that really counts. When a great change takes place in any environment it is a good thing to know what the effect has been. What has been done in the beetle-kill area of Colorado should be done where dams are built or fires burn, or disaster of any sort falls. Some species thrive. Some species or other are sure to be hurt.

We are given now a plan for power transmission lines which involves a rational use of plant sprays. May someone always be at hand to praise when any corporate body, public or private, makes a wise use of sprays! If we tried to do it the other way round we could not—the priests of Baal have done their worst on hill and vale throughout the land and there are not enough prophets to curse them all. Surely Egler is optimistic when he says we are doing it wrong only 90 per cent of the time. That means 10 per cent of power line mileage is treated wisely, which would give real hope of ultimate victory, because, fortunately, the good is cumulative.

The general picture of improvement of farm land for wildlife, as painted by Marshall does not look very bright. So vague and empirical do the programs seem that it is hard to measure their value, and so far as producing more wildlife is concerned, we haven't got very far yet. Of course we should never expect a formula to solve our problems. No two tracts of land are exactly alike. We could reasonably expect more in the way of controlled experiments to tell us whether we are producing more wildlife or not. However, under any dispensation, I feel that we should still have had to cover the same old ground, and the Soil Conservation Service and others, who have treated large acreages should not feel too discouraged. Farm pond and water impoundment schemes still look good.

For the pine woods of the South, Reid offers us the hope that a judicious modification of the burning programs favored by foresters and livestock men may add a good crop of quail without interfering with the other two crops. Multiple use was a new term not so long ago, but now the new chief of the United States Forest Service boasts, and justly so, of the broad basis of his planning, and the chief of the Soil Conservation Service is in the same position in presenting his plans for farm lands.

We have an interesting group of papers on moose, from the outer limits of the moose range. In these widely separated areas they seem to be thriving. Alaskan caribou evidently are not. Nothing in the world causes more resentment than the Cook's tour expert who spends a few days in the field and pontificates for the rest of his life. What anyone can get out of a short visit depends on what physical and mental equipment he takes with him, especially the latter. Leopold and Darling are an ecological team that would be hard to equal. Alaska is a big country, but so is my own bailiwick, and I would be glad to pick their brains for two months, let alone the four they spent in Alaska. The suggestion that forest fire prevention and suppression could be more important than predator control in the management of caribou is a challenge that we may hope will not be met just by leaving time to tell. The cost of forest protection being what it is, the answer may hinge on what finally happens to a caribou herd that has been increased by wolf control. We can share misgivings at the psychology of scarcity dictating regulations to control the harvest of an increasing moose population. What about cows? Can we ignore the lesson of Sweden, where last year, after years of cow shooting, the record total of 22,848 moose was killed, and still the sportsmen's congress concluded that there were too many moose? Some people in Alaska surely know these things, but a good clear statement is invaluable.

The professional wildlifer Lehmann is one of the rarest of the genus, a professional wildlifer who is not even indirectly a public servant. The rest of us hope that such men can get out and do the things we dream about, because we still, on the whole, believe in the efficiency of private enterprise, though we cherish a fondness for free public shooting, meaning about ten dollars a bird out of pocket, but nothing to the landowner except some free advice on spending his own time and money. There is nothing like the challenge of achievement in wildlife management or any other field. The game production of the densely populated countries of western Europe is a challenge to us now but it is too far away to be effective.

Lehmann's paper was about the Vitamin A reserves of quail. It's a nice technique and we are given a nice set of figures. When he concludes that a good quail harvest will always have to be mostly young birds, and you can't save them up, except maybe in the deep freeze, he has been chewing on an alphabet of vitamins. Let's add to quail, grouse, huns, pheasants, rabbits, muskrats, *et cetera.* The biggest mistake we made on our Ontario pheasant proving ground at Pelee Island was in not killing enough birds the first time the population was up. Game can stand a lot of shooting, as Black shows us clearly.

Pollution is still as tough a nut to crack as ever. We are told that as long as oils and greases, not to mention other agents, are discharged into the Detroit River, ducks are going to die because of them. We can add that as long as municipalities are unrestrained, industries will balk at restraint. Conservation is a grand thing until the greater good for all cuts off the immediate good for a few. Then it is a fight. We are not fighting much yet and we have still to restore a damaged river, somewhere, to its pristine glory.

The pollution battle is a David and Goliath struggle, where the admonition "Let not him that putteth on his armor boast himself as he that taketh it off" still holds. David won, of course, but it was the nimbleness of his brain and not the strength of his arm that did it. Wisconsin has been armed for years with good legislation, a constructive program, and a will to see things through. They have good reason for some restrained boasting. However, I find more similarity to David in a sportsmen's group in England, where there are no pollution laws, but just the Common Law. An anglers' club, the Pride of Derby Angling Association, have just recently put off their armour after a stern court battle with the City of Derby and the British Electricity Authority—a municipality and a government corporation. The city is restrained from putting its sewage into the Derwent river. What caught my eye was an approving editorial that did not hesitate to say that the city had no more right to put its muck into the river than the citizens have to put theirs on the front sidewalk. As for the British Electric, all they were putting into the river was water — warm water that raised the temperature to the injury of trout and salmon. They must not hurt the trout and salmon any more. Don't think for a minute that they and the city didn't put up a fight. All we can say of the Pride of Derby Anglers is that they have yet to learn that you can't have trout and salmon in a river flowing through an industrial area. Maybe they never will learn.

Few discussions on conservation education have ever before been called technical. It seems as though one of the problems is to formulate the problem. Then we can teach the teachers. When we run into trouble getting some innovation accepted we know that people just don't know what is meant by such phrases as renewable natural resources, sustained yield and multiple use. If you see a state that is having a particularly sticky time you can bet that its own paid staff at the levels that meet the public do not understand or approve of the innovation. It is more than possible, of course, that what the technicians wrote and said was incomprehensible, but when it comes to jargons we have also the stale journalese of professional writers, as uninspiring as stale beer. It is even worse when the experts have changed their minds—or as they say, there has been a reassessment of values. As Bill Severinghaus remarked in a deer session of former years, it was the conservationists who put across the buck law, and it took them years to do it. You get the situation where A Company marching in the van doesn't hear the About Turn, or misunderstands it, and disappears over the hill while the rest of the battalion is off in the opposite direction. That sort of thing can happen easily in the conservation army because so many officers are self-appointed and they are all hollering at once. Nobody likes such confusion. Well-disciplined groups are bound to appear. The task of orienting them is for the various leaders. With that accomplished, we can appeal to the unoriented rabble. Appeal we must, because in a democracy the rabble public still controls supplies.

When we are baffled by public indifference or hostility to a worthy program, we can be sure that people just don't know why we want what we do. Our stock public relations devices, the news releases, the magazine, the exhibit and the picture show, may be operating away off by themselves, contributing nothing to solving our problems. The Missouri film and bulletin on the quail are outstanding examples of the right kind of educational material, the kind that smooths the path of resources management.

However, you are stumped from the start if you haven't got your own men with you. This Conference should be especially famous for its emphasis on the workshop technique, especially for in-service training. New Hampshire is evidently away to a first-class start.

Though education, like charity, should begin at home, there is hardly an administrative unit on the continent that cannot do most of the things set forth by Chester Wilson for his all-out educational campaign. These things all fit very well into one pattern with the schemes and proposals of other speakers and this means that our educational session has been worthy of its technical label.

If I have any criticism to offer of the Technical Sessions, it is the small number of papers on fish. Surely with the Dingell-Johnson program in operation there are some things that should be shouted from the housetops. I think the fisheries men will admit that both the Dingell-Johnson and Pittman-Robertson programs arose in the atmosphere created by these Conferences. In fact the two ride along together, as fisheries and wildlife quite generally do, across the continent. Maybe in another year one session could be devoted to the appraisal of the two together. Meantime it does us no harm to realize that all is not fish, even in the sea.

There have been many extra-curricular activities at this Conferonce, but I am going to mention only the work of Lansing Parker and his helpers at The Wildlife Society Employment desk. There is only one thing worse than a man without a job and that is a job without a man. The benefit of this work well done will be felt for a long time and we are grateful to both the men and the jobs for showing up at the desk.

I come now to the waterfowl session just concluded. Presumably, while a technical session is a place for facts and facts alone, a general session gives some play to the emotions. The recurrent general session on waterfowl seems to share the characters of both. Regardless of Conference themes and slogans it is a hardy perennial. Some of the material has been technical enough, too, and the technical men speak with studied restraint. I am glad that Anderson let himself go. He is another wildlifer free from the mildew of discretion that cannot help but bloom on public servants. Anderson deals with ducks that wander up and down the whole continent, but when he says, "Show me the land which can provide unrestricted use by man and waterfowl," we know he is right. All he asks is that we earn the public support we need by arming an intelligent and influential minority of duck hunters with facts.

We are left in no doubt that the future for waterfowl is uncertain, after hearing of the advance of agriculture into the breeding grounds and the resulting conflict of interests. Dushinske, in particular, yesterday painted a gloomy picture of the best waterfowl breeding grounds in the States and it is a pity that the new chief of the Canadian Wildlife Service could not have sounded a more cheerful note on his first appearance at a Conference. About the only encouragement was Marshall's enthusiasm in an earlier session over the small impoundments scheme in New York, which some of you waterfowlers may have missed. You can't balance an impoundment in New York against a pot-hole in North Dakota, but there are still, as we have been shown, many things states can do for waterfowl.

With few ducks, as compared with 30 years ago, we are running into more and more grief. The reorganization in the U. S. Fish and Wildlife Service and the various states to meet changing needs is a very fine development. Instead of being baffled, senior enforcement men do the work of biologists to cope with new complexities, and biologists get out and arrest violators.

I wish I could say something more specific on significant trends and probable developments. The program practically begs me to look into my crystal ball, but I never did have one that worked. When I inquired about picking one up here in Washington somebody finally told me that they had all got broken back in '48.

The best that I can do is to try to lead you into the train of thought in which I find myself when I think of what our job is in relation to an obviously critical state of world resource management. I suggest that while the world's renewable resources are deteriorating and we have just cause for worry, we are still living in a society which is more propitious for organized conservation than any other in the present or the past. True, our own population is increasing; it isn't only the Chinese. However, we have been told convincingly that it is in the proper management of our already occupied areas that the hope of supporting the increasing population lies. When it comes to a broad consideration of all resources we lack mainly the feeling for husbandry, what Leopold called the "Ecological Conscience." We need, to paraphrase Dr. Lively, a restoration of faith in nature without any loss of enthusiasm for science. What we bring under management we can keep there for a long time to come. We need to present the challenge of accomplished fact. The more successfully we can, each of us, manage his own vineyard, the better we can hope to withstand future pressure and even make headway against it. The pressure is real, and the task is urgent, but we can go a long way yet.

The population of England and Wales is now more than one person per acre, yet there is unquestionably better shooting than 150 years ago when the population was only one person to five acres. In fact, and this is interesting, it was not until the population had passed the level at which it could be considered self-sustaining, in terms of the land in which it was located, that game management started to go ahead. At the present level recreational land use of all types is intensified, and there is no constant relationship between the sale value of land and its agricultural production. If that is a result of not being self-supporting it is something we should not see here. I hope, however, that we shall see all types of land esteemed on the basis of multiple use. That was the way it was done in the Doomsday Book.

And now, as our northern Indians always say to the interpreter before they go on talking, that's all I have to say. I know it's too much, yet it expresses but poorly the helpfulness of the Conference. Here's your very good health, a safe journey home, and happy and fruitful labors until we meet again next year.

ACKNOWLEDGMENT OF APPRECIATION

C. R. GUTERMUTH
Vice-President, Wildlife Management Institute, Washington, D. C.

Friends, everyone appreciates that it is an arduous task to summarize and appraise the entire program of a Conference of this magnitude. In fact, it is a real job merely to read the many papers that are presented in the General and Technical Sessions of this international meeting. Nevertheless, Dr. Clarke did an excellent job. I have not been able to hear many of the presentations, but Doug's critique will be studied carefully during the next few weeks in an effort to overcome some of the mistakes of the past in formulating the programs of future conferences.

We are at the close of another successful conference. Before adjournment, I would like to say that, in my opinion, this has been one of the most outstanding of all of the North American Wildlife Conferences. The registration was about what we expected, and, fortunately, we did not have quite as many outside attractions to entice people away from the meetings as in Miami last year.

The reception and annual banquet last evening was a tremendous success. We were honored by having 175 Senators and Congressmen in attendance. Certainly those legislators from practically every state were impressed by the high quality of people interested in this work, and with the serious devotion that pervades their entire thinking and course of living. I feel confident that all of you enjoyed the musical and variety show that was produced by the Jack Morton Company. It likewise was gratifying to see so many remain for the premiére of the Walt Disney film, "Prowlers of the Everglades." The attendance at the dinner was 870 persons, which is something of a record.

In behalf of the Wildlife Management Institute, I wish to express sincere thanks for the splendid cooperation that was received not only from those who participated in the program, and who attended the sessions, but from all those in the different organizations, societies, and agencies, who continue to help make these annual meetings progressively better.

The success of the yearly conferences cannot be measured in attendance alone. The location, weather, local attractions, and even the national economic conditions can affect attendance—so we must measure the interest that is manifested in the discussions, and the contacts that are afforded, in judging the need for the continuation of these yearly gatherings.

We want to express sincere thanks to The Wildlife Society, and especially to Dr. Victor H. Cahalane, for helping to formulate a diversified and well-integrated program. Vic did a splendid job, and he, along with the other members of the General Program Committee, are the ones who deserve most of the credit for the success of this year's conference.

We are indebted to Mr. Clarence Arata, and his staff in the Greater National Capital Committee, for helping to provide adequate facilities for this large group of people from all over North America. His agency also handled the conference registration, and as was expected, we did not have a single complaint.

I am sure that you agree that it is a real pleasure to attend conferences in a Statler Hotel. The Statler management seems to be able to anticipate all requirements. They have a knack of meeting emergencies, of which there always are many, even with the best of planning.

Meeting as we do in the larger cities, it is difficult to get good coverage in the local press. The metropolitan dailies usually have more news than they can use. This is true especially in the nation's capital. Nevertheless, we do appreciate the space that was given the conference, and we are grateful for the items that were put out by the wire services.

If you have not registered, please do so immediately. We will print the names of the entire enrollment in the published TRANSACTIONS. Incidentally, you should order your copy of the Transactions as early as possible. The Institute prints the proceedings of the annual conferences on a cost basis, and this year's Transactions will be edited and mailed in the shortest time possible. Mr. Trefethen will do his best to break the previous release date record.

At the close of the last two conferences, I expressed thanks to a couple of people who always are around when needed, who do a lot of work during the conferences, and who get little compensation for their efforts. They actually live these meetings the year round, since they must put up with Dr. Gabrielson and with me during the planning stages. I hope that Mrs. Gabrielson and Mrs. Gutermuth are present, and that they will stand and take a bow. Thanks for the generous applause; those ladies really deserve it.

Now then, here are the attendance records. At the last check, we had registered 1,356 people from all 48 states, and from seven provinces of Canada. Others were here from Mexico, Sweden, and Pakistan. We had a total registration of 1,203 at the 1949 Conference here in Washington, so we have broken all records except possibly for the 1936 Conference that was called by President Roosevelt.

Incidentally, we never are able to get more than about an 80 per cent enrollment, so there probably were at least 1,500 people in attendance this year.

The record banquet attendance was 687 people at the 1948 Conference in St. Louis. There were 647 at the '49 banquet in Washington, so the total of 870 last evening is by far the all-time banquet record.

We will not decide on the time and place of next year's meeting until adequate hotel facilities have been guaranteed. The dates will be early in March. You may be sure that we will pick a convenient location. It is hoped that we will see all of you and many others next year, and thanks very much. A safe trip home and happy landings.

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[1]Compiled by Lee E. Yeager

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