TRANSACTIONS

of the

NINETEENTH NORTH AMERICAN WILDLIFE CONFERENCE

March 8, 9, and 10, 1954

Palmer House

Chicago, Ill.

Edited by James B. Trefethen

Published by the
WILDLIFE MANAGEMENT INSTITUTE
WIRE BUILDING
WASHINGTON 5, D. C.
1954

Additional copies may be procured from
WILDLIFE MANAGEMENT INSTITUTE,
Wire Building, Washington 5, D. C.
for $2.75 Postpaid
(U. S. Currency or its equivalent)

PRINTED IN
U. S. A.

Printed by
MONUMENTAL PRINTING CO.
Baltimore, Md.

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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 Nineteenth North American Wildlife Conference.

THE NORTH AMERICAN WILDLIFE CONFERENCES

The Wildlife Management Institute is indebted to many individuals who contributed to the success of the 19th North American Wildlife Conference. The names of the committeemen who contributed time and energy to the development of the program are found on the preceding pages. Special mention, however, must be made of the services of Mr. Lansing A. Parker who represented The Wildlife Society as Chairman of the Technical Program Committee. Mr. Parker, in cooperation with his associates of the Society, formulated an excellent technical program of broad public interest. Dr. A. Starker Leopold provided an inspiring Appraisal of the entire Conference Program which will serve as a guide for the planning of future conference programs.

A brief review of the history of the Conferences will reveal the tremendous progress that has been made in the improved use and management of the natural resources of North America. Although designated the 19th North American Wildlife Conference, this meeting actually is the 40th consecutive annual gathering. The first National Conference on Game Breeding and Preserving was held in New York City on March 1-2, 1915, under the auspices of the American Game Protective and Propagation Association, later known as the American Game Protective Association or American Game Association. Attendance at the early meetings consisted largely of game breeders and citizen conservationists rather than the scientists, research workers, biologists, and state and national administrators who attend the meetings today. The Proceedings of the 15th Conference in 1928 were the first to be published in book form.

In 1929 the name of the Conference was changed, but the numerical sequence of the Transactions was retained. The meeting held in that year was called the 16th American Game Conference and this name was continued until 1935. The 19th was the first three-day conference and the 21st was the last of the series of conferences held under the sponsorship of the American Game Association. On August 25, 1935, the American Game Association decided to discontinue functioning as an active sportsman's agency but to retain its charter and continue its legal entity. Sponsorship of the annual Conference and other work in which the association had engaged during the previous 24 years was delegated to the then recently organized American Wildlife Institute.

The first North American Wildlife Conference was called by President Franklin D. Roosevelt and was held in Washington, D. C., on February 3 to 7, 1936. The Transactions of this conference were printed and distributed by the Bureau of Biological Survey of the U. S. Department of Agriculture. The second through the eleventh North American Wildlife Conferences were under the sponsorship of the American Wildlife Institute.

Prior to 1936 all conferences had been held in New York City, but beginning with the 1937 meeting the policy has been to hold the assembly in various cities and regions over the continent so that representation will not become regionalized and so that the meetings will be representative of geographical interests.

On May 8, 1946, the Wildlife Management Institute assumed the public activities of the American Wildlife Institute. The name of the American Wildlife Institute legally was changed to the American Wildlife Foundation, later the North American Wildlife Foundation, and it became the first national foundation for the conservation of natural resources. The program in operation at that time was expanded materially by the Wildlife Management Institute and in 1947 this organization sponsored the 12th North American Wildlife Conference, which was held at the Plaza Hotel in San Antonio, Texas.

The 19th North American Wildlife Conference was the second of the present series of meetings to be held in Chicago, the last meeting there in 1944. Attendance at the present conference represented 47 of the 48 states, Alaska, Mexico, and most of the provinces of Canada. A total of 577 guests at the annual banquet filled the ballroom of the Palmer House to capacity. The accompanying list showing the total registration and banquet attendance at the past nineteen conferences indicates the tremendous growth of interest in these public gatherings, which have become the clearinghouse for information on renewable natural resources and their management.

Year	*Place*	*Total Registration*	*Banquet Reservations*
1936	Washington, D. C.	1,372	------
1937	St. Louis, Missouri	748	------
1938	Baltimore, Maryland	756	412
1939	Detroit, Michigan	813	260
1940	Washington, D. C.	751	336
1941	Memphis, Tennessee	787	------
1942	Toronto, Ontario	339	220
1943	Denver, Colorado	424	305

1944	Chicago, Illinois	502	223
1945	Cancelled	—	—
1946	New York, New York	710	532
1947	San Antonio, Texas	684	503
1948	St. Louis, Missouri	984	687
1949	Washington, D. C.	1,203	647
1950	San Francisco, California	1,155	494
1951	Milwaukee, Wisconsin	1,008	459
1952	Miami, Florida	890	574
1953	Washington, D. C.	1,356	875
1954	Chicago, Illinois	1,009	577

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PART I

GENERAL SESSIONS

GENERAL SESSIONS

Monday Morning—March 8

Chairman: THE HONORABLE JEAN LESAGE
Minister of Northern Affairs and National Resources, Ottawa, Canada

Vice-Chairman: SAMUEL H. ORDWAY, JR.
Chairman, Natural Resources Council of America; Vice-President, Conservation Foundation, New York City, New York

OWNERSHIP AND USE OF RESOURCES

The first general session of the Nineteenth North American Wildlife Conference convened in the Ballroom of the Palmer House, Chicago, Illinois, at 9:00 a.m., the Honorable Jean Lesage presiding.

FORMAL OPENING

IRA N. GABRIELSON
President, Wildlife Management Institute, Washington, D. C.

It is indeed a pleasure to be here to open the 19th North American Wildlife Conference. These Conferences always are a source of inspiration and enjoyment to me, and I hope that this applies to many others who attend.

In these opening remarks, it has been customary for the benefit of those who are attending for the first time to inform them that this meeting does not pass resolutions or develop action programs. This is a forum-type meeting for the discussion of public questions; for the presentation of new information; and for the discussion of new problems in the major conservation fields of this continent. The discussions are broad enough to include soil, water, forests, vegetation, and wildlife, in contrast to the programs of earlier years which confined their attention to wildlife. We have long since learned that the proper management of all renewable resources is closely interrelated and that it is not possible to separate them, either in our thinking or in the action programs, without doing more harm than good.

This Conference, therefore, passes no resolutions. The information that is developed in the discussion is for use in your own action organizations. Both the Izaak Walton League of America and the National Wildlife Federation are holding their annual meetings immediately after this Conference, and unquestionably those organizations will use some of the information secured here as a basis for their future programs. Many other organizations hold executive committee or business meetings during this Conference. It is for these organizations, rather than for the Conference itself, to formulate action programs, and the chairman of each session is requested to refuse to entertain resolutions or motions.

In opening the conference last year, I remarked that at the advent of a new administration, Washington was full of the "gimme boys"—those people who want something for nothing out of the public resources. I expected that most of the old efforts for invading or destroying the national park system, wildlife refuges, national forests, and other areas reserved for the public would appear in one form or another. A review of the past year indicates that my prognostications were quite accurate. At no time since I have been in Washington have those who represent the efforts to destroy or to convert to their own use such public resources been more active or more aggressive.

It would, therefore, seem to be in order to review briefly what has occurred. The new administration has had a year to find itself and to establish a conservation program. In general, it can only be said that no constructive, progressive program for advancing conservation activities has yet been developed, and little interest has been shown by the two great departments responsible for the most important of our conservation estates in protecting the gains made in the past. It is fair to say that no dynamic program has appeared in the major conservation bureaus or the departments which administer them.

Let us review briefly the record to date.

The Interior Department has refused repeatedly to take a positive stand with regard to the perpetuation of the national parks and monuments and wildlife refuges for which it is responsible. There have been repeated statements that each and every attempt to invade or destroy parks and refuges will be judged on its merits. This seems to be a euphonious way of saying that if political pressures become strong enough, we want to be in a position to yield to those pressures.

The Department of Interior has been willing to oppose the timber raid in Olympic National Park, but it has recommended the destruction of the Dinosaur National Monument, this latter on the somewhat nebulous theory that they will save some water loss by evaporation. Yet, in the same breath, they propose the huge Glen Canyon Reservoir farther downstream on the Colorado and at a lower elevation. Because of its location, this much larger body of water presumably will sustain a much greater evaporation loss than that which might occur at Dinosaur. Perhaps the fact that evaporation losses at Glen Canyon will be charged to the upper river water allocation makes it appear desirable to find some peg upon which to hang an appeasement program to the upper river states. Dinosaur seems to be the victim.

In addition, they proposed the expenditure of $21 million to develop a Coney Island type of recreational set-up on the reservoir that would destroy the Dinosaur, and put this kind of an amusement outfit in the midst of one of the greatest scenic wonders of this land. A lesser sum than the $21 million (which is not yet available but which will be requested) would make the present magnificent Dinosaur readily accessible by good roads.

The department has not shown any interest in the Metcalf bill, H. R. 6081, which, if enacted would give it an opportunity to do a much better job of administering the Taylor grazing lands.

The Interior Department made a favorable report on H. R. 4646, one of the crudest attempted land grabs in recent years. Representatives of the Department testified in favor of the D'Ewart bill, H. R. 4023, the stockmen's attempt to pull down the administration of the national forests to the low level that prevails on Taylor grazing lands. It liberalized the migratory bird hunting regulations beyond the point justified by its own reports on breeding success. Whether or not this has brought an exessive kill this year is not known.

The record of the Department of Agriculture is equally unimpressive. It emasculated the Soil Conservation Service's technical staff, and no one can yet tell how adverse the effect of this action will be on the basic soil conservation program. Most conservationists believe, however, that it will be very bad.

Agriculture prepared a strong adverse report on the D'Ewart bill which was suppressed somewhere along the line by behind-the-scenes pressure. It also sent to the Committee an equally strong adverse report on H. R. 4646, and then withdrew its objections under pressure.

Both departments have taken practically all of the top positions in the conservation bureaus out of the career service and laid the ground work for this or future administrations to fill these conservation posts with political hacks.

The Public Lands Committee of this Congress, under the chairmanship of Congressman D'Ewart has distinguished itself by its consistent and constant efforts to help the "gimme boys." The D'Ewart bill, sponsored by the chairman of this committee, would have given the livestock operators a first and second mortgage on all of the national forests. It would have placed them in the same advantageous position that they now occupy to the detriment of the public interest on state-owned lands in the West as well as the Taylor grazing lands. The Committee reported out H. R. 4646, which was introduced by Congressman Ellsworth. It took out the safeguards that he had written into the bill in an effort to make it easy for certain large lumber companies to make an open raid on any national forest, wildlife refuge, or national park. The administering agency would not have had anything to say about which land would have been given to the companies, and under the terms of the bill they could have taken any land that had timber on it without regard to the use that was being made of the land or the importance that it might have to the community in which it was located.

The D'Ewart mining bill, H. R. 4983, a bill to head off legislation to correct present abuses under the mining laws, was also reported out. Certain members of this committee have gone out of their way to ridicule and discredit anyone who came there to oppose these and similar propositions. No Congressional committee has taken favorable action on good conservation measures that have been introduced, such as the Metcalf bill, H. R. 6081; the Johnson bill, H. R. 1037, to make Dinosaur a national park; and many others.

The brightest spot in the picture has been the Congress itself, which has refused to go along with these attempted raids. H. R. 4646 was beaten on the floor by an overwhelming vote (226 to 161) and sent back to Committee. The D'Ewart mining bill, H. R. 4983, was killed by three objectors when placed on the consent calendar. There was so much adverse sentiment to the D'Ewart grazing bill, H. R. 4023, that it never got out of committee, but it is certain that it would have been beaten if it had been reported to the House. I am hopeful that a similar fate will greet other bills of this nature.

The selfish interests never quit, however. Certain stockmen have maneuvered to get other bills introduced by Senator Aiken and Congressman Hope, both good conservationists. The bills, as introduced, with the exception of one or two clauses, are comparatively innocuous. Nevertheless, the Senate bill has been amended in committee to give the stockmen pretty nearly all that they would have gotten under the D'Ewart bill, and if it is reported out in that form, it should be beaten as soundly as H. R. 4646. Hearings have been held in the House on the companion Hope bill, but up to the present, there is no information as to committee action.

Conservationists have been aware of these dangers, and it is their activity in alerting Congressmen who are interested in these public resources that has made it possible to hold the line. They have had no help from the officials who are responsible for these public resources. Only as you and your fellow citizens who believe in maintaining and managing these public lands continue to take an active interest, can they be maintained for public use for the generations to come. If you relax your vigilance and your effort, they will melt away, and once they are gone, it will be difficult, if not impossible, to replace them. There are few places in this country where it would be impossible to create an additional national park of a caliber equal to those that we have now. Dinosaur National Monument is one of them. It should be a national park, and perhaps your interest can be extended to the point where it will be made one.

In conclusion, may I express the hope that the conservation forces continue to gain in strength not only to protect what we now have but to continue to push ahead in obtaining better management of our renewable natural resources.

In behalf of the Wildlife Management Institute, I hope that each of you will profit from this meeting and go back home with new information and new enthusiasm for the tasks ahead.

INTRODUCTORY REMARKS

THE HONORABLE JEAN LESAGE, M. P.
Minister of Northern Affairs and National Resources, Ottawa, Canada

It is indeed an honor which I greatly appreciate to have the priviledge of acting as chairman of this first general session on so important topic as that of ownership and use of resources. My role today should be limited to two things: introducing the very distinguished guest speakers who will address you and watching the clock.

However, I would like to tell you how happy I am to meet so many of you who are dedicated, each in his own field, to ensuring that natural resources shall be a sound and permanent foundation of national life. Already you have achieved much, and your presence here is evidence that you are preparing for greater efforts towards ever higher achievements. This Nineteenth North American Wildlife Conference is a healthy symbol of the growing awareness of the people on this continent that our welfare—indeed, our continued existence—depends ultimately on the way we conserve and use the natural wealth which Providence has so bountifully bestowed on us.

We here look upon ourselves as practical men, and justly so. I hesitate to think what would happen if I were to describe this Conference as a gathering of philosophers. Yet, as resource administrators, that is what we must be if we are to advance or even maintain our present position. In relation to Nature man must be either a destroyer or a conserver; he cannot be neutral, although he may delude himself into thinking so. Conservation is more than a profession or a science: it is also a philosophy. In the practice of conservation both faith and works are necessary; either, alone, is sterile and profitless.

I know of no better expression of the philosophy of conservation than that given by one of the great men of our time, the late Aldo Leopold, in the chapter entitled "The Land Ethic" in his book *A Sand County Almanac.*

If Aldo Leopold had written nothing but that chapter, his exposition of "The Land Ethic" would have qualified him to take his place with the great philosophers of all time. It should be read and reread, not only by those entrusted with the use and management of natural resources, but also by every teacher, by every administrator, in fact, by every person who believes that mankind has a tomorrow as well as a today. To read it should make us both humble and proud: humble, to realize that man is but one of the many parts which go to make up a whole, and that in our unwise striving for our own enlargement we have too often been a liability rather than an asset in the balance sheet of the universe; proud, because we have it in our power to remedy past mistakes and to justify our existence to the other creatures whose world we share.

We are the fellow-creatures of the birds and the beasts, the grasses and the trees, as well as of the other peoples whose brotherhood we acknowledge. We have learned the hard way that cooperation between nations is better than warfare; we are still learning the hard way that it is better to cooperate with Nature than fight against her. We can win skirmishes and campaigns, but in the long run we cannot subjugate Nature—we must ally ourselves with her, or perish.

When we have learned that lesson, we have taken a long step towards wisdom in our use of the earth's resources; but it is not enough. We realize that we are a part of Nature and must work in harmony with her; but, in addition, we must realize that each of the resources which we use or dominate is also part of the whole, and unless there is harmony in our treatment of the several resources, we introduce shattering discords. At times it may be difficut to see how the development of seemingly competitive resources can flourish simultaneously; but to say that one or the other must be suppressed it to admit defeat. We must work as a team. We shall have to make mutual adjustments to develop mutual strength. We may well have to compromise on practical details in order to establish more firmly our hold on basic principles.

It is an excellent thing that we, who have so many different responsibilities, can meet here to discuss our varied problems in this friendly atmosphere. Each of us aims at the best development of the resources in his own field, and at the same time is prepared to listen to the views of workers in other fields, to examine methods of cooperation, to compromise if necessary, and to work always for the general good and not for sectional advantage.

It is of particularly happy augury that this is, once again, an international conference. In this great central city, we have come together from Mexico and Canada as well as from all quarters of the United States of America for a neighborly discussion of problems which are not limited by man-made boundaries. Speaking as a Canadian, I deeply appreciate the friendly cooperative spirit of which this gathering is symbolic. I am proud and happy to be able to reaffirm Canada's desire to continue to work with her sister nations of the North American continent for our common welfare and prosperity.

BROAD OBJECTIVES OF OWNERSHIP AND USE OF LAND

SHIRLEY W. ALLEN

Professor of Forestry, School of Natural Resources, University of Michigan; Member, Michigan Conservation Commission, Ann Arbor, Michigan

Ownership and use are not the same thing, nor is the owner always the user.

But ownership is recognized, theoretically, as a reward in terms of property, for labor, proven ability, and social attitude as a land manager, or sometimes, unjustifiably, for mere acquisition through shrewdness, speculative skill, or some other vague accumulation of power.

Use by the owner of land (meaning natural resources), and arrangements by the owners for use by others than himself, is within certain limits, under control of the owner, and whether it amounts to productive use or mere exploitation is a responsibility of society as well as of the owner and the user.

To me, there seem to be two broad objectives to be sought in the ownership and use of land. The first one has to do with making our system of land ownership work in practice to produce what the user needs and is entitled to. The second has to do with developing the attitude toward the land which is ethical rather than one which assumes that land is property only.

Ownership and use of land therefore calls for public policy. The statement of this policy amounts to the social theory of property, namely that private property is established and maintained for social purposes. And what are social purposes? In general, the greatest good to the greatest number for the longest time. A corollary of this theory is that such land as cannot be owned privately and used with assurance of satisfactory service to society, shall be owned by the people collectively—shall remain in, or gravitate to, public ownership. Just how firmly we believe in such theories hinges principally on what we think is "good" and to what extent we think society as a whole is entitled to this good. We are great rationalizers and by using the magic phrase "the American way," we can make the social theory of property work just about as we individually please. This is certainly true if we are one of the owners of land or in a position to influence the decision as to who shall own land.

This state of affairs—this attitude toward ownership and use of land—has given us a pattern of land ownership in North America, which is largely unregulated and which varies tremendously in rendering the service to society which we have the right to expect. The farmer, in spite of his troubles and marketing trials, will insist that private ownership of agricultural land brings it into the greatest service to society. The logger is just as sure that the timberland which can be a source of profit should be in his hands. The livestock man wants ownership or control, and we have examples of both, of the range, and takes credit for social use. The developers of water for its various uses rebel somewhat at regulation of use, if not at ownership, in producing services. The mining and oil companies have a mixed pattern of ownership, regulation, and control but will tell you that they can serve society better with less regulation and more ownership. We are great rationalizers. The sportsman, commercial fisherman, and trapper would be much startled if accused of rendering anything but service to society by their activities, but seem content with the public ownership of the wild animal resource, even though it prowls, crawls, runs, flies, or swims over privately owned land. Our first broad objective, therefore, seems to me to be this:

> In view of the established ownership pattern, to make this pattern work for the greatest benefit of mankind by understanding what is the greatest good, by insisting upon the production of this good by the owner, as the price of ownership, and by gearing our own use to this understanding and this insistence.

I doubt if anyone would argue that this is not an important one of our objectives or that there is anything narrow about it. But which of our conservation activities are beamed toward realizing it?

First of all, our effort to maintain and to increase the productivity of renewable natural resources, regardless of whose property we may consider them, breaks down into two kinds of work. The one is physical and usually technical, even to the extent of propagating wild animal forms, artificially reforesting denuded lands, or changing methods of farming, both in the selection of crops to plant and in fitting the soil. The public, whether the formal owner or not, is sometimes more active in these three fields than the private owner. This is natural in the instances of managing wild animal resources, scenery, range lands and water. It is less to be expected in the instance of managing soil and timber, and yet the physical and technical acts of management draw heavily upon public help. The other kind of work is legalizing selling ideas, and financing. These do not involve physical nor technical handling of the resources, but they make possible a physical program and facilitate such a program.

Perhaps the only lesson we can draw from separating the physical and technical from the legal and persuasive is that a knowledge of each is helpful to the other. Much of our legislation ignores the findings of research. And much of our actual recommended management is too little cognizant of administrative difficulties. These difficulties are real, and in the cautious machinery of a democracy, they can only be met by understanding and dealing with those hard-to-understand reactions of the individual—the man who glories in the feeling that he is free. Perhaps we need a research project to try to understand what leads a man whose livelihood comes from the soil to let that soil get away from him or become unproductive; why the logger is still too willing to say that timber is a one-time crop; why society has, for so so many years, slept on its rights, participated in and condoned the fouling of our waters; why the mining interests, in rearranging the materials in the earth's crust into machines, buildings, and energy, feel no responsibility for damning the landscape; and to bring it closer to our own group, how it is that a sportsman can call himself a conservationist and waste his kill?

This isn't the kind of a research project we have undertaken. We have been too willing to assume that human nature cannot be changed and that the profit motive, human cussedness and, more to the point, intellectual and moral laziness cannot be regulated or otherwise dealt with.

Shall we turn to brain washing, to other totalitarian methods? Shall we depend on the advertisers? These people and their methods are having considerable success in manipulating what we call human nature. Can we change the human nature of land owners and users by passing laws? Is there some deeper and more fundamental way of marshalling physical action, persuasion and policy making, so that we shall achieve an understanding and a delivery of what is good for the greatest number for the longest time?

These questions lead to what seems to me to be our second broad objective and it is difficult to untie from our first. But we shall never fully achieve the first, that of making our pattern of land ownership work without coming to terms with the land on an ethical basis.

Thomas Jefferson, Henry David Thoreau, Gifford Pinchot, Governor Frank O. Lowden, John Muir, and other great North Americans have hinted that there should be an ethical relationship between man and the land in its broad sense. But it was left to the late Aldo Leopold to develop the idea more fully. It is from his thinking that I would state our second broad objective in the ownership and use of land:

> To carry our ethical concepts beyond our relations with our fellow individuals and with society in general and to work for the acceptance of the thing which Aldo Leopold called the con-

servation ethic or the land ethic. This means an active belief in the rights of soil, water, forests, natural pastures, scenery, space, wild animal life and even the minerals, and a regard and a reverence for these resources.

Achieving any such an objective involves something of a revolution, and revolutions, even those that stretch over long periods, never succeed without leadership. Moreover, leaders themselves must be sold on the objectives. So, our first step is to accept and believe *ourselves,* in the land ethic; the second step is to influence others to accept it. All of this involves a challenge to mankind as the lords of creation. It assumes a measure of humility.

The Psalmist almost said it in addressing the Creator: "When I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; What is man that thou art mindful of him? and the son of man that thou visitest him?"

He must also have been thinking of the *land* within the universe. But he lived in another age and for a free American who reads, listens to, and views on his television set the notes of an ever-expending economy with its small attention to maintaining our natural resources, belief in a land ethic is quite an undertaking. Influencing others to believe in it is still more difficult, but it should be a part of family training, taught in our public schools, explained in every sportsmen's club, and even sounded at meetings of trade associations and chambers of commerce. It should even govern the enactment of laws and regulations. Its connection with land ownership and use takes us back to the familiar phrases long trumpeted by conservation forces—"beneficial use," "trusteeship," "obligations of proprietorship." Nor has this trumpeting been lost, even though many have written their own tickets for these proclamations of responsibility.

And we well may ask ourselves again, which of our activities are beamed toward realizing this second objective—the acceptance of an ethical attitude toward the land—toward natural resources as a whole?

Strangely enough, whether ecologically or philosophically, an ethic is a limitation of freedom of action as an individual, either in the struggle for existence or as a member of society. So perhaps our restrictive laws, our somewhat superficial efforts to prevent waste in an expanding economy, our conservation pledges, our announced but not fully accepted statement that conservation is "use while fostering," and in short, our sentimental statements about the good earth which we forget so readily—perhaps all these are the beginnings of an acceptance of, and a campaign to win acceptance for the the land ethic. I hope they *are.*

It is always more difficult to sell the elements of an attitude than it is to create an interest in physical action. And that is why I should have numbered the two broad objectives differently. Certainly we can hope for a better program of action in ownership and use of land as our ethical sense improves, but both objectives must be sought simultaneously and continually. They are no less our broad objectives. And whether we like it or not, our one hope for a lasting desirable program of ownership and use *is* a wider acceptance of an ethical relationship toward the land, by its most destructive users, namely, people. Even since Leopold remarked that progress in conservation still consists largely of letterhead pieties and convention oratory, we have made progress, and in spite of the difficulty of gearing a respect for land to a technological age, I believe that an increasing measure of respect is attainable.

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OWNERSHIP AND USE OF NATURAL RESOURCES: THE NATIONAL VIEWPOINT

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I am intrigued by the general theme of this conference: "Natural Resources—Whose Responsibility?" These resources are so important that I long ago became convinced that full national sentiment and participation must be mustered to protect them. I also have been around enough to know that most of the real jobs are done by a relative handful of intelligent, dedicated souls such as I see in this audience—and that is not said as mere flattery.

However, I am becoming much more hopeful of general understanding of the real issues involved by my association over the past several years—as an observer—with the soil conservation movement. In hundreds of farmers who are cooperating in the work of soil conservation districts I have watched an awakening of interest, then accomplishment on their own farms, then a missionary zeal to spread the gospel of saving topsoil and water, and finally an appreciation of what conservation and proper use of all natural resources mean to all the people, present and future. So I look ahead with more optimism than, as an essential Malthusian, I once had.

You may wonder why I was picked to talk on the national viewpoint as regards ownership and use of resources. You're not half as puzzled as I am. I was too busy these past weeks to ask Mr. Gutermuth. Otherwise he might have discovered my shortcomings and relieved me of this responsibility. I am a newspaper editor and writer who has made conservation his special interest. But I have not followed closely the discussions of these matters in previous national or international gatherings, I haven't had the time for diligent research, and I hope you will be satisfied with a statement of what in the main may be only personal observations—or confusions—of limited scope.

Some conservationists fear, some hope for a change in the attitude of the Federal Government toward resources with the change in administrations from one party to another at Washington. The New Deal and Fair Deal administrations gave great encouragement to expansion of federal activity in many fields relating to natural resources. Appropriations were generous, I think we all will have to admit, whatever niggardliness we saw in respect to our own pet projects. In these activities, as in so many things under the Roosevelt and Truman regimes, centralization was the order. The present administration has given many indications of a shift from that attitude—appropriations are being reduced, states' rights are being stressed.

Like all of you, I often have wondered just where to place the proper boundaries around federal, state and private ownership of natural resources, or the control over those resources. Most of you are acquainted with "A Policy for Renewable Natural Resources," which was adopted by the Natural Resources Council of America and presented to the North American Wildlife Conference at Miami on March 18, 1952. That policy says in part: "The orderly development and application of a comprehensive scientific conservation plan for every farm, ranch, small watershed and other operating unit of the nation's land and water are imperative, and can best be achieved through the efforts of locally controlled groups." In a statement accompanying the policy, the Council says: "Planning for the development and use of natural resources can be handed down from on high, as is being done now in much of the water development, or it can grow gradually from the ideas and needs of the local citizens and groups most concerned. The latter, which is in the American tradition, promises the greatest returns over the longest period of time."

I am largely in agreement with the Council. Yet there have been many instances where the people immediately concerned were too selfish or too blind to recognize a problem of resources depletion and would not have recognized it until too late if some governmental agency hadn't observed things and called attention to what was going on and offered help. I love the people—I happen to be one of them—but I don't always trust one man or a group of affected men to make a proper decision about some question which has national implications. And so many of these natural resources questions—even the seemingly local ones—do have national implications.

I am thinking about soil conservation particularly, and that is what the Natural Resources Council largely had in mind in stating its policy. It is within the memory of almost every person here when Hugh Bennett first got a few people aroused over our disappearing topsoil and started the Soil Conservation Service as a federal agency. Every one of the 48 states had a chance to get busy on that obvious problem—or it should have been obvious. So did every local unit of government, every landowner. But if any of them saw the problem, they did almost nothing about it. Even after the federal agency got going, states were slow to fall in line and supplement the work of the U. S. soil conservation service. Many states and localities still are lagging, although cooperation by state officials is generally good now.

This is not to argue against winning the aid of local interested groups. They should be encouraged to take the initiative. That awareness of conservation problems is what I was talking about at the start of my talk—more and more people alerted and offering hope for the future. But emphasis on that local participation need not shunt aside the fine assistance of the trained federal technicians who were responsible in the first place for the mobilizing of opinion and personnel to fight erosion and other waste.

In traveling about the country I keep asking questions about natural resources and who should control them. In some of the western states I have had attention called to the great amounts of land in federal ownership, well over half the total of some states is so held The states should own and control that land, I have been told. Or it should be sold to private interests. I seem to have an inherent sympathy with such views—I believe in private enterprise and in states' rights. Yet it has been my observation that selfish interests are able to make a greater impression on state governments and agencies than on the Federal Government and federal agencies. This seems particularly true where the state populations are small. I am thinking of such things as the grazing of cattle in public forests and on public ranges, of exploiting public timberland and waters.

I feel sure that in my own state—Minnesota—the State Government would have had far less success in making a roadless, planeless area of a million acres along the Minnesota-Canadian border than the Federal Government is having. The objectors are so vigorous and persistent that they might well have defeated the wilderness plan if the State Government had attempted to put it across, even though the overwhelming majority of citizens acquainted with the project gave their approval—as has been the case. Such an outcry as has arisen from a few resort owners and airplane pilots would have intimidated many state officials.

The wilderness program is one where federal control is clearly indicated, in my opinion. The national interest is concerned, for the wilderness is intended as a refuge for all people, not only Minnesotans, perpetually. Indeed, there is an international interest, for this is only a part of the great Quetico-Superior program which embraces large tracts on both sides of the international boundary. To perpetuate the near-virgin character of the zone requires federal ownership of all land within the roadless area a goal which slowly is being realized.

But what about the Superior National Forest, within which the roadless-wilderness area lies? Is there any good reason for that huge expanse being in federal control and largely in federal ownership? Hasn't Minnesota a forest service of its own which is capable of handling such holdings? Minnesota owns more of the timberland within its own boundaries than does the Federal Government. Well, I suppose nobody has the complete answer on just what the division of ownership should be. Here is the division in Minnesota of about 20 million acres of forest land:

3¾ million acres in federal ownership.
4 million acres in outright state ownership.
5 million acres under county control, technically state owned.
7½ million acres in private ownership.

This division works out very well in Minnesota. There is cooperation and friendliness among the various owners. Some of the large companies which need a continuing supply of timber have been increasing their holdings, reducing the acreage held by counties. While the Federal Government wants to increase its holdings in particular areas, as in the wilderness zone, this will be accomplished largely by an exchange of present holdings with the state or with private owners, so an increase in federally owned land in Minnesota isn't likely—probably the trend will be the other way.

Even though Minnesota has an efficient forest service, it is doubtful that the state could undertake—at least for some time—the work or expense of the Federal Government's four million acres. The federal service provides forest fire protection for all lands—federal, state or private—within the boundaries of the national forests. And the Federal Government reimburses Minnesota for the fire protection which the state provides for federal holdings outside the national forests. In many states where I have heard gripes about federal ownership, the gripers probably haven't considered how much more state or private ownership would cost.

The question of federal ownership of natural resources might be answered one way theoretically, but an entirely different answer may be required practically. The Federal Government already has the ownership, its agencies are well established. Thus in each state, and in the country as a whole, the decisions must be made from the situation as it actually exists. Things probably would be different if a new, entirely undeveloped state were admitted to the union today. When states were admitted they gave little or no thought to conserving natural resources. The chief aim was to exploit whatever was handy as quickly as possible. The government kept title to much of the land it already owned and when conservation did begin to enter men's minds, the Federal Government took the lead. For that initiative and for the standards which the federal agencies quite consistently have set, the states and the people should be forever grateful.

I have spent a lot of time in Alaska. I was a war correspondent there. I visited the territory every year—sometimes for months at a time—between 1943 and 1948. I went back last summer to check up on things. I have watched statehood sentiment develop. I happen to think that Alaska is not ready for statehood, but many of my discerning friends up there think otherwise. One of the reasons I am doubtful is this matter of resources. The Federal Government is the great owner of land and forests. The plan is to turn over to the new state great quantities of this land. Territorial politics have some shortcomings and, though I may be doing many Alaskans an injustice by my suspicions, I can't help but feel that control of the natural resources will be better handled—at least for some time to come—under present arrangements.

I visited Hawaii this winter and did some snooping around, as usual. The political situation there leaves me with many misgivings, though it may be that statehood would help to cure some of the political shenanigans. About the conservation of natural resources, however, I don't have the same doubts I hold in regard to Alaska. The resources of the island seem pretty well protected, regardless of ownership. At first, when I saw how the sugar plantations operate, I wasn't so sure. Sugar is grown year after year, decade after decade, with no organic matter returned to the soil. On experimental fields the residue from sugar cane has been put into the earth, but no discernible benefits resulted. So I just had to conclude that Hawaii was the exception which proves the rule about humus in the topsoil.

Now the stateside question is: Where do we go from here? I may be poaching on the preserves of the man who is to follow me and give the state view on these ownership and control matters. But I freely grant him the right to get into the national aspect in his presentaion. I call attention to a "State Conservation Program" which Chester S. Wilson, Minnesota's commissioner of conservation, made in 1946. Mr. Wilson, who has a part in this conference, told me the other day that this program represents policy on state responsibility for conservation in Minnesota.

Here is a statement from the program: "The State, as the basic unit of government, owning or controlling a large portion of the natural resources within its borders, should assume responsibility for conservation to the fullest extent of its capacity, leaving to the Federal Government only such conservation functions as involve a national interest and cannot be effectively discharged by the State."

Mr. Wilson also said in his biennial report in 1946: "Federal encroachment on the proper field of state activity has usually occurred because the state itself failed to meet some public need. It cannot be said that the state of Minnesota has yet measured up fully to all the needs of conservation within her borders. . . . It is folly for the state to attempt to shift any of its proper burden of conservation work to the Federal government. The state thereby weakens its control over its own interests. State agencies, if adequately supported, can respond to local needs and handle local problems more promptly and effectively than federal agencies under remote control."

Most of us probably would agree in large part with Mr. Wilson. One big trouble, however, is that states don't always adequately support conservation activities. Soil conservation—which I have mentioned—is a good case in point. That movement no doubt would be far behind its present accomplishments if the Federal Government hadn't taken the initiative and provided the funds.

The Federal Government has undertaken some questionable things in the natural resources line which state governments surely would not have undertaken. I refer to the so-called conservation payments under the old PMA program. I say "so-called" because many of the payments had no connection with real conservation practices, although the program has been tightened up under present auspices. The payments were a scheme—and to a great extent still are—to spread public money among the farmers. Many of the self-respecting farmers I know were against the payments, particularly during the lush war and immediate postwar years. State legislators would have a tough time extracting tax money from their constituents for such a program. So, as Mr. Wilson implied, federal control may not always be best.

I hope I am not expected to serve as the unqualified defender of federal ownership and control of resources on this panel. I forgot to ask Mr. Gutermuth. If so, the centralizers may be disappointed. As I have said, my instincts are all for states' rights. Yet I think most questions of federal ownership and/or control of natural resources should be decided on the basis of national interest. Clearly there is a national interest—or at least more than one state's interest—in such things as range and forest management. Watershed protection is involved, and a watershed and its effects on streams usually cross state lines. States can enter into compacts for regional ventures, but this arrangement has drawbacks. There is a national interest in recreation, especially in these days of easy travel, and it isn't hard to defend national parks and most national forests.

But the Federal Government can blunder through on projects, which, as in the case of ill-advised soil conservation handouts, would not otherwise be undertaken. I have in mind the shotgun-marriage program for the Missouri Valley, particularly the big dams—which my good friend—but no relative—Elmer Peterson of Oklahoma calls "big dam foolishness." Navigation on the Missouri probably is in the same class.

During the sluggish 1930s I spent some time in the TVA country and became quite an enthusiast for that big affair. Here, a least, was somebody doing something in a period when so many were afraid even to think of moving forward. TVA probably never would have gotten started except as a federal project, supported by federal funds. Yet I am not sure that the Tennessee Valley is so much further ahead than it would be now if there had been no over-all authority. Certainly other regions have made comparable progress without similar federal paternalism. Many of the things undertaken by TVA were properly the business of private enterprise. Yet if you want to argue that the federal example there and elsewhere has been a salutary prod to states and to private enterprisers, you may well be right. If you want to say that federal ownership and control have deterred much private enterprise, you no doubt are right in part.

Maybe what I am trying to say is that there is no simple answer to a division of ownership and control of resources. I was reminded the other night of a situation in Norway. Dr. Malcolm Hargraves of Rochester, Minn., was showing colored slides from an European trip to a group of conservationists. One of his pictures was of a mountain forest. The tract was privately owned and subject to supervision by a government forester. By tradition, the farmers of the neighborhood had run their cattle in these woods, regardless of ownership. So strong was the tradition that neither the owner of the woods nor the government forest service dared try to change things, even though the cattle were killing off most of the replacement growth. And the situation is not too different in some of our southern and western states.

This conference is directed principally at renewable natural resources. If I may be permitted to include non-renewable resources for a moment, I could make my position on government ownership and control clearer in that field. I incline toward giving title to underground riches, as oil and metals, to all the people. The old common law interpretation that a man's ownership of a parcel of land extended down to the core of the earth and up to the sky is being discarded, though slowly. Man is being recognized as a custodian of natural resources and when he doesn't acquit himself well, or when the public interest is better served by another arrangement, either the State or Federal Government should step in. I like the arrangement in western Canada, whose oil fields I visit from time to time. The province owns the mineral rights, except in those cases where ownership was estabished by private interests before present laws went into effect.

In renewable resources I feel sure there is room for all types of ownership, with an integration of practices in managing those resources which takes into account the public good. After all, we are more concerned with the protection of forests, streams, land, etc., than with who owns what. But if the Federal Government, which in the main has been a responsible steward of the holdings now in its control, is to surrender any ownership, I caution that the moves be made carefully. Once the land passes into other hands, reclaiming it could be a most difficult assignment. Buying up the land in the wilderness area has demonstrated that.

Well, this may be an elementary—or perhaps confused—picture I have presented. I hope it is not as wide of the mark as the one I read about recently in a news item from California. Perhaps you saw it. The teacher had asked her pupils to draw a picture based on any Bible incident. Johnny's picture showed three figures in a big automobile of most modern design, quite evidently speeding at a great rate. The teacher told Johnny that surely his picture didn't illustrate any biblical happening. But Johnny knew better. "That's the Lord driving Adam and Eve out of the Garden of Eden," he explained.

Thank you.

OWNERSHIP AND USE OF NATURAL RESOURCES: THE STATE'S POINT OF VIEW

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When a Westerner is handed the subject of ownership and use of natural resources he immediately thinks of the federal lands which comprise 54 per cent of all the land in the 11 western states. These are the so-called ''public land'' states. These lands can be placed in two separate categories, first—that type which has been set aside for a single purpose such as national parks, national monuments, wildlife refuges, military reservations, atomic energy commission lands, power lines and irrigation project rights-of-way and reservoir sites; second—a larger area encompassing the national forest, public domain and Indian lands which are managed for multiple uses and administered by the Departments of Agriculture and Interior.

I assume that the lands and the resources with which you are primarily concerned are those that fall in the latter category—those which are generally considered for multiple-purpose uses. These are the lands which no one wanted title to a few short years ago when they were available under the various claims and homestead laws. They were the marginal and inaccessible lands. Today the pattern has changed. The competition for land and resource use is extending far into the back country. Accessibility is no longer a problem. Much of the virgin resources have been cropped from the patented lands; so in many cases, from a relative point of view, the once marginal lands are now highly valuable. However, many of the public lands are in a run-down condition and are far from being adequately productive.

These once-marginal lands now have taken on a significant value, not only for private enterprise but for the public as a whole. They are the shooting grounds for the sportsmen, the playgrounds for the recreationist, the watershed areas for domestic, agricultural and industrial use. They also provide resources for timber and livestock industries as well as open lands for mineral prospecting and development.

I have been asked to speak on the state's viewpoint pertaining to the ownership and use pattern of these lands. I believe no one person can present the state's point of view because there is no unanimity of opinion on the subject.

Many of these lands are vital component parts of livestock operations. Without the public lands a high percentage of these operators

[1]In the absence of Mr. Nelson, this paper was read by Dr. Seth Gordon.

would be denied a balanced year-long range. Ranchers have stated that they can not afford to own these lands because of the tax burden. Although they form keystones to many economic ranch units, the land carrying capacities are not commensurate with the potential tax burden.

As far as timber is concerned, these lands were the least desirable and most inaccesible areas at the time they were open to patent. However, under current economic conditons this timber is now demanding a high stumpage price on the competitive market. Usually this high price recognizes that the buyer has not had the burden of heavy carrying charges over a long period of years. There are some who would urge that these public timber lands be distributed to private ownership in order to stabilize private enterprise and place the lands on the tax rolls. A logical method of acomplishing such distribution has not been proposed. To divide these lands into small holdings may be disastrous from a resource management viewpoint. In dealing with low productive capacities or crops that require many years to mature, only areas of considerable size can be properly and economically managed in private ownership. As an example of how such a program would be accepted if sufficiently sized operatable units were distributed to private holdings one need only review the failures in establishing combined public and private timber holdings into "sustained yield" units for long-term operations. These proposals brought forth charges of monopoly, preferential treatment and inequities from small timber operators. This widespread opposition precluded the establishment of such programs and halted a theoretically sound approach to good resource management and use.

Coupled closely with this problem of ownership is the problem of local taxation. The public land counties and states are confronted with serious tax problems, and these become much more real in forested areas as old growth timber resources are cut out and such industrial activities are reduced. In the far western states this becomes more serious when we study the migration of populations. For example, the impact of a half million new people each year in California has increased the cost of government for the necessities of schools, hospitals, water supplies, sewage disposal, and institutions of all kinds which are becoming a burden upon the taxpayer out of all proportion to his current ability to produce the necessary capital. In many public land counties bond issues to meet such public service demands for schools alone are straining the credit limits. The problem of these population pressures should be recognized beyond the borders of the local county and state. Relief could be provided by some type of "in-lieu'' tax payment for the public lands—the states too should recognize this need for some types of state land ownership. The need for some such aid will become more and more essential as we convert from a virgin-resource harvesting economy to one of managed second-growth economy for at least the time required to make the transition. To foster sustained productivity of our renewable resources, it is important for the states to create a tax climate that is favorable to private industry. On the other hand, it is also necessary that all lands, public or private, bear their fair burden of the cost of government in relation to their productivity.

A problem that is of ever-increasing worry to administrators of public recreational lands is the constantly growing maintenance bill for these areas. A number of proposals have been made to solve this problem for the national forests in the form of bills to provide for earmarking a percentage of forest receipts, special-use stamps, and other related methods of raising maintenance money. None of those to date has met with unanimous accord among all types of users of the national forests. However, this operational problem on these lands, both federal and state, must be met, and the public must realize that ''pay-as-you-go'' is a consideration in public land management for recreation.

Growing populations are demanding room in which to spread for recreational purposes. Because of these pressures and the carelessness of people many private land owners have been forced to close their lands to recreationists and sportsmen. Private hunting clubs for both big game animals and waterfowl are putting more and more pressure on the public shooting grounds. The lack of good outdoor manners and appreciation of the value of private property by sportsmen and recreationists have forced the landowners to close their holdings. On the other hand real progress is being made in ''permitted use'' of private lands under cooperative agreements with Fish and Game Departments. So far this method is most successfully used for upland bird shooting although some states have adopted similar plans for deer and antelope hunting on private lands.

One possible solution to ease recreational and hunting demands on public lands is to provide low-cost access to unused or little-used parcels of the public domain. This principle can also be extended in the case of many coastal states to provide low-cost access to inter-tidal public fishing areas. Studies should be made by public lands states to determine the feasibility of providing such low-cost access compatible with other land uses.

If our population reaches the anticipated 200,000,000 people by

1975, the productive capacity of our wildlands, public and private, is going to be severely strained. They are going to have to be placed under more intensive management if we are to maintain our present standards of living. In many areas we are already late in getting proper resource management started. However, progress is being made in the fields of forest practices, range improvement, water development, pollution control, etc. In most of these fields our knowledge of how to secure maximum production is woefully lacking because of inadequate fundamental research.

How to secure maximum water yield; minimum soil erosion; how to establish good forage cover on lands of low productivity; how economically to get a second-growth forest growing on cut-over lands; how to maintain a balanced wildlife population; how to control noxious plants, insects, and disease are some of the unsolved problems that handicap maximum economic production of all our wild land resources.

At present we do not have enough basic physical facts about our resources of soil, timber, grass, minerals, wildlife and water to enable us to make adequate plans and programs for our future economic support. There are a few areas in which existing ownership patterns should be adjusted and legal machinery should be established to make this possible. Examples of such areas are: townsites, where public ownership is restricting normal and healthy community expansion. These "townsites" should be reasonable in size and not designed to cover a whole mountain range; boundary adjustments to establish more logical administrative units; land exchanges to consolidate both public and private holdings for more efficient resource development and management. With the exception of such adjustments I cannot speak with authority on the state's point of view in regard to the ownership and use of our wildland resources. I have endeavored to establish some of the problems that are connected with our present patterns but because of the great variety of interests and conflicting philosophies in land and resource development, management and use, I doubt if there exists a general consensus of what the pattern should be.

It seems to me our major concern should be in how to get maximum production and use of all our resources regardless of who owns them. After all, whether they are private or public we are merely temporary "stewards of the land" charged with the responsibility of "conserving its resources and productivity from generation to generation." Maximum production implies multiple use. Yet we must recognize that all values are not equal and therefore the most important value must receive first consideration.

To accomplish these objectives we need inventories, research and education. We need resource inventories to determine where, what, and the extent of our natural resources. We need research to develop the techniques and know-how properly to reproduce, manage and protect these resources in order to secure maximum usable production. We need education geared to disseminate this knowledge and assist in applying the fundamental principles that will assure an economy of abundance for the future.

With this basic understanding and the ability and willingness to use it I believe the problem of ownership will lose much of its significance.

OWNERSHIP AND USE OF NATURAL RESOURCES FROM THE CONSUMER'S VIEWPOINT

J. W. PENFOLD[1]

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I have been assured that when one is put on the spot as I have been here—trying to pinch hit for so distinguished a man as Senator Liebers—that some liberties with the subject can be taken, are expected, and will be forgiven. I expect I shall take some of them.

Certainly I am a consumer—was one of the 90 million in 1910, am one of the 165 million today. I may not be around in 1975, but there will be some 35 million more to take my place at the mourner's bench—200 million in all, and we won't have reached our peak then.

Representing the consumer's point of view in this discussion, I thought I had better check up and find out what a consumer is. Webster describes him quite succinctly, as one who consumes—"one who uses goods, and so, diminishes their utility."

And again, Webster gives "consume" as meaning: "to destroy, to spend wastefully, to use up, to waste away, to perish."

Such definitions are not very pleasant sounding. As a matter of fact, they are downright frightening. But looking at the history of our country and what we've done with and to our resources and the products of our resources, we probably must concede that Webster is not too far off the beam. Ours *has* been the most prodigal of civilizations. We *are* the most consuming of races the world has ever seen. Not only are we such but we are braggarts about it. Seldom does

[1]Mr. Penfold substituted for State Senator Otto Liebers of Nebraska, who was forced to cancel his scheduled appearance because of illness.

a chamber of commerce ever miss an opportunity to construct headlines around some compilation of statistics which show a gain in the *quantity* of goods and services consumed in its community.

Perhaps a better criterion, both as to quantity and quality, would be a coordinate set of statistics relating the expenditure of goods to the resources diminished, wasted away or destroyed in producing them.

Would a more shrewd analysis of the situation include, not only the number of loaves of bread sold in Chicago today, but also what that may represent in grasslands plowed up by suitcase farmers and speculators gambling on moisture and two dollar and a quarter wheat? Meanwhile the dust is blowing in large sections as fiercely as it did 20 years ago. We were supposed to have learned our lesson then—but I wonder.

Maybe along with the totals of paper produced from pulp, we should relate what that means in terms of clear-cut woodlands where no sustained yield program is operative, or in miles of stream destroyed by pulp mill effluent.

Would a recap of rangelands destroyed by overgrazing be a better indicator of where we're headed than the reports of receipts at stockyards? Should a tally of cans of beer sold be accompanied by another tally—the number of empties to be found littering our highways, stream banks and lake shores?

Is it not amazing that our engineers proudly detail in their water development projects and list as a benefit the fearful amount of reservoir storage space? And they must provide for silt. Not only that, but we're told that storage space is insufficient, and future generations will have to do something else about it.

Is it not strange that most of our western trout fishermen look hopefully to Game and Fish Departments for ever-increasing plantings of catchable-size fish as the answer to constantly diminishing trout waters, due to pollution, dredging, damming, ruined watersheds, which are much too frequently accepted as signs of "progress"?

In that same category, we find our critical winter big-game ranges constantly shrinking—as a result of "progress" again—and our very competent game managers, who do know the score, spend sleepless nights trying to figure how they can achieve necessary reductions in game populations.

Is it not ironic that we did not succeed until just this last year in getting underway, on a pilot project basis, watershed protection and upstream flood control program under the Department of Agriculture? In my home state we have one of those projects; it's about ready to roll, and we've very happy about it. The farmers and ranchers, the soil conservation district folk, have only been trying to get something comprehensive done for the past 20 years. Ironic, isn't it, that the sub-drainage selected for this pilot project, in an area where as much as 75 per cent of past flood damage has occurred, totals only slightly more in acreage than the acreage of highly productive bottomland which would be inundated by the huge flood control reservoir proposed downstream on the main stem? But, small as it is, it is a big step in the right direction. Let's hope Congress takes action to continue this program.

But getting back to the consumer: If we look pretty sharply at our record, and keep Mr. Webster's definition in mind, I think we are drawn irresistibly to the conclusion that the consumer's viewpoint toward resources and the products of resources must run something like this:

"Give us assurance that the things we eat, wear, use and enjoy will be replaced and replaced time and time again as they are destroyed, used up and wasted away."

There must be a corollary to that also: "Do *whatever* is necessary to provide that assurance."

In America, where we've had such a stupendous back-log of natural resources, we've been able pretty much up to now to take all that for granted. Most of our people just take it as gospel that the daily paper and the bottles of milk will be on the doorstep in the morning. I'm reminded that one of the most visited of exhibits in the Central Park Zoo is a plain, ordinary milk cow.

We have been able to assume these things, and the assumption has grown continually in direct proportion to the increase in percentage of city dwellers and to the increase in technology of production and distribution. We have not yet felt the pinch, but it's coming, and there are an abundance of symptoms.

I wonder if the continuing pressure on all categories of public lands, for grazing, for timber, for minerals for all types of commercial use, isn't a symptom of the impending pinch. Dr. Gabrielson has mentioned the "gimme" boys; he could have provided many more examples and a lot more detail.

We are definitely feeling the pinch in the western states when it comes to sport fishing; we're feeling the pinch with big game animals in many instances—pressure to fence the public domain to the detriment of antelope, for example.

We are feeling the pinch on water, for sure. And it's certainly interesting to note that presumably the unanswerable argument for the construction of Echo Park dam and the loss of an irreplaceable national monument, is an estimated additional evaporation loss of 100,000 acre feet. At the same time the Colorado basin states are losing some 24 millions of acre feet through seepage between diversion point and delivery to farmers head gate, and from that point on close to 50 per cent of the balance is wasted through inefficient irrigation methods.

The best answer, actually the only answer I've received, to that appalling water waste is that it would be uneconomic to line ditches and do the other things necessary. They say we can't affort it. I ask, can we afford not to? Must we wait until we've destroyed everything we can before we go ahead and do what we'll eventually have to do—and should have done in the first place?

We are feeling the pinch in our national parks, monuments and national forests with vastly increased public use, and strictly inadequate funds for taking care of that use. We're feeling the pinch in pressure to alter or destroy great national park units such as Dinosaur, Kings Canyon, Glacier and others.

We are feeling the pinch in timber drain beyond allowable cut because of inadequate timber access roads. I am sure Colonel Farley and Clarence Cottam have from time to time discerned a pinch on available migratory waterfowl. We are definitely feeling the pinch of pressure on wilderness, and wild areas, and unhappy enough, sometimes from the very people who want wilderness and who have reponsibilities for it.

Perhaps more important than anything else is an apparent willingness on the part of some elements of leadership to accept the viewpoint that it is being "impractical" to accept less than the best; that in achieving some values we can ride roughshod over other values; that in giving the people what they appear to want we are safe to destroy other things which they need.

It was interesting at a recent congressional hearing to be questioned again and again by one gentleman who sought to obtain an admission that irrigation and power is more important than recreation, that we can safely destroy the latter to obtain the former. I suppose the brain is more important than the heart, the heart more important than one kidney, the right arm more important than the left, if you happen to be righthanded. But if we are, as we proudly boast, a race of geniuses, should we not be able to achieve a relative abundance of all the elements that go to make us up, including the morning paper, the bottles of milk, the wheat, the beef, the trout and salmon, automobiles and TV, including Liberace, and the chance to be humbled and exalted by some superb natural scene placed here by our Creator?

By and large the consumer viewpoint has not been very constructive—he places demands upon demands—prodigal today, careless of tomorrow. He is not too concerned about who owns resources, because he knows that ownership, as we think of it, can only be a temporary thing, that true title to resources remains always with the people. Yet on a few occasions he has come out swinging to protect his own rights in the public lands, and he'll do it again. When he really feels the pinch, he will insist that his needs and wants, all of them, be satisfied—*whatever* it takes.

But there has been a growing consciousness in the people of their own relationship to their environment, an increase in understanding of what good stewardship of resources means. To the extent that this is true, to that extent we must congratulate the people and groups represented here today in this hall. For you people primarily have been carrying that load and with understanding and devotion. The educational process is never easy, and it is particularly difficult to inculcate the broad ethical concepts, so ably expressed by Dr. Allen, in a "nation of salesmen." Educational programs are hardest to sell to top administrators, who too often throw up administrative blocks and most always select information and education as the first place to economize.

In spite of all that progress has been made. Nowhere is that more evident than among our young people. I don't think we need to worry much about the leadership for tomorrow if we do with them the kind of job we should today.

The consumer is invariably an optimist; I certainly am. I don't doubt for a moment that eventually we shall work out these resource problems, all of them. I think the consumer, in his cumbersome, uninformed and groping way, hopes that you people will be able to work them out, before we, the consumers, have so destroyed, used up, wasted away and spoiled our basic resource wealth, that severe limitations will have been placed on our ability to live thoroughly and happily in the future.

The consumer does want to help in this all important job, but you will have to show him how.

THE PRODUCER'S VIEWPOINT CONCERNING OWNERSHIP AND USE OF NATURAL RESOURCES

ROY BATTLES
Assistant to the National Master, the National Grange, Washington, D. C.

I am a farmer, and as such I'm a great believer in private enterprise. Private ownership, sparked by the profit motive under a system where that motive can function, is one of the basic ingredients in this nation's amazing record of progress. The dreamers can think of all kinds of arguments as to why public ownership of all natural resources and all production facilities would serve the public interest better than our present system. Some of their arguments sound valid. That's because our private enterprise system is not perfect. Public ownership and operation, on the other hand, is almost universally far less efficient. It leads to spiralling bureaucracy. Bureaucracy leads to across-the-board stagnation. Public ownership kills the profit spark that is needed to kindle and maintain the fire of progress. It opens up all kinds of avenues for political manipulation, graft and unsoundness. A publicly owned facility never goes bankrupt. Bankruptcy, while hard on the people involved, buries inefficiency and opens up the road to a better way.

In short, to try to correct the problems of our private ownership system by any process that leads to nationalization is, to my way of thinking, like killing "the goose that laid the golden egg." This is not to say that private business, in some cases, does not need judicious regulation. The public interest may best be served by such regulation, provided the "profit or progress" incentive is not materially hampered. Too often, on the other hand, regulation gradually kills competition, and the public is harmed rather than benefited. In the case of out-and-out monopolies, public ownership or a public utility type of regulation is probably necessary until some better system can be found. And then too! there are a few projects that are too big for private enterprise. Atomic energy is an example. Multi-purpose projects, such as some of our big dams, are often not feasible for private investment to handle. Some natural resources that are in limited supply and that are vitally essential to the public interest should not be available for *exploitation* and must, therefore, be protected until substitutes are found, or until such time as they are no longer vital.

I doubt if I need to remind you, however, that it is very difficult to denationalize anything once the bureaucrats are entrenched. This is mererly to face up to the political facts of life. It would seem imperative that any program of proposed public control or ownership be preserved only of extreme necessity, and then only after all other possible avenues of accomplishing the desired results have proved fruitless. It would also seem that in the field of regulation and public ownership it is desirable to retain, insofar as possible, those characteristics that are inherent in the private enterprise system for self-evident reasons. As Woodrow Wilson once said, "The history of the expansion of liberty and opportunity for individuals is the history of the restriction of the power of government. When we resist the expansion of government, we are resisting the powers of death."

Now for a look at the natural resources that those of us who make our living on the land are intimately connected with. These include soil and water, plus a crop that might well be termed a natural resource—namely, timber. All three of these resources are renewable. True, after they are seriously damaged or almost completely lost, it is expensive and time-consuming to replace them. Despite this, however, there are few areas where public ownership is justified.

This is not to imply that we should *not* have certain goals set up in the public interest for handling problems related to soil, water and timber. For the most part, what is in the public interest is profitable for the individual farm operator. Therefore, a program of education, technical assistance and in some few cases direct tax subsidies, should be and are being pursued to implement, on a voluntary basis, the goals that have been established. One of those goals is a good living for the farmer and his family. Another is ample supplies of nutritious food for a growing population. A third has to do with producing food more and more efficiently in order that consumers will have a substantial portion of their spendable dollar available to buy those other things that contribute to a high standard of living after their food bill has been paid.

Although substitutes have been found to compete with our fiber and timber crops, these crops are still integal parts of our national needs, both on and off the land.

Good "on-the-farm" management of soil and water, furthermore, is in the public interest in that it is intimately connected with flood control, siltation problems, and available water supplies for other segments of our economy.

Sound land use practices, along with wise management of timberlands, contribute more than anything else to good wildlife habitat. There are other goals, but I doubt if the validity of the above goals can be questioned.

Devoting every acre of land on the nation's 5,000,000 farms to its wisest use is objective number 1. Those hillsides that are too steep or are otherwise unsuited to hay or pasture crops should be devoted to sod crops, namely, grasses and legumes. Other farm lands may be cropped as heavily as is feasible from a wise land-use viewpoint. This can be accomplished under a system of private ownership.

Good land use, of course, must be accompanied by other wind and water erosion control devices. Farmers are now beginning to learn *to walk* water off of the slopes without serious erosion damage. This is done through the use of such devices and practices as contour cropping and cultivated terraces, division ditches, strip cropping, sod waterways, etc. These techniques, along with good land use, allow a maximum of the rainfall to soak into the ground. These techniques, furthermore, will be and are being implemented privately.

Ample amounts of organic matter or humus are essential for high crop yield, good soil tilth, and water conservation. Farm practices that add humus to the soil are being used more and more under our present system of farm ownership and operation. Of course poor sods or poor tree crops are less effective as water conservers and soil holders than good ones.

This is where lime and fertilizer, new seedings and plantings, plus other good practices, pay off. Perhaps "pay off" is the correct term to use here also, since these practices pay off in terms of dollars and cents.

Now I imagine that most of this material is old stuff to you. Some of you will point out that our national average level of soil productivity is still going down. I will have to admit that you are right. On the other hand, I would point out that we have made enormous strides on the land during the past quarter of a century. Actually, we are now entering a whole new broad era of "know-how" on the farms of America. True, the know-how is far ahead of its general use, but the gap is narrowing.

My point is simply this: We can and will protect the greater share of our nation's most important natural resource—our soil—(including water), under private ownership. Also on farms where this is neglected for some reason or other, it can be rebuilt. It can be rebuilt in a surprisingly short time. The nation, furthermore, can afford to rebuild these eroded or over-cropped lands without the inherent dangers that come with a system of compulsory rules and regulations or public ownership. Too much is lost in terms of our basic freedoms and production efficiency in this latter course.

Getting back to our public policy in terms of long-range goals, I think that we can do much as individuals and collectively through government to aid farmers in bettering their own lot and serving society at the same time.

We have only scratched the surface in the process of *educating* farmers. The Extension Service needs to be expanded as does the Vocational Agriculture System. Some farmers still do not understand that in the long-time run good land use and good conservation are generally profitable.

We have never given the Soil Conservation Service enough trained, high-caliber manpower to provide farmers with the technical assistance that they need. More research money is another basic necessity.

We have never fully faced up to the problem of the small, low-income farmer, who contributes little total production to the market place. I'm glad that a study of this problem is high on the list of objectives of the Eisenhower Administration. We must recognize that a poverty-stricken farmer is often not "conservation minded," nor able to afford good land use practices, even though they pay off in the long-time run. He often overcrops and cuts back on his lime and fertilizer purchases in an attempt to make ends meet. This is merely an effort to say that fair farm prices are of interest to far more people than the individual farmer himself.

In the field of direct and indirect subsidies designed to accomplish proper use of the soil as a natural resource, some subsidies can and are being used to help and encourage farmers to get the job done. These subsidies are only justified, however, in that they serve the public interest and to the extent that they serve the public interest. If such practices are profitable to the farmer within a reasonable length of time, then to my way of thinking they are *not* a public obligation.

I have in mind some of the subsidies now being paid through the Agricultural Conservation Program for practices that are in the public interest, but that do not pay off rapidly to the farmer. Tax reductions for soil building practices are justified under many conditions. Subsidized credit of the "supervised type" is a government responsibility on the small, low-income farm. Tax reductions to encourage good timberland management also seem to have merit.

All of these are small but important aids to individual private enterprise farmers.

Attention should be paid also to land tenure—keeping the farm in the same family over a period of centuries and to some method of compensating tenants at moving time for their soil and water "build-up" contributions to the farm.

Forest lands and some of the God-forsaken areas, particularly in the far west, present a special problem. Some of these areas are so worthless and devoid of potential value that the government acquires them by default or has had them from the beginning. A glance at an ownership map of the western one-third of the nation reveals at least one-half of the land there is owned by the states or the Federal Government. This is alarming, and particularly so in view of the extreme difficulty in retiring areas that have profit potential into the hands of private owners. It's next to impossible to get it done.

Grazing and timber regulations in some of these areas seem necessary.

Parks, game preserves, and public recreation grounds are for the most part public responsibilities.

Getting into the forestry problem, however, I have always felt that if adequate fire protection could be achieved, and if the areas could be policed against timber thieves, large sections now in state and federal forests might well be sold to private owners who are interested in a sound, long-range, well-managed investment. Good forestry practices are profitable. Some strings to prevent "clear-cutting" and "slaughtering" might have to be tied to these sales. I would like to see this tried, except where the forests are used as recreational areas. I do not like huge governmental holdings, although if the above plan, or something better, does not work, *then perhaps public ownership is the only answer.*

I must admit that the average farm woodlot is for the most part a dismal failure in terms of its potential. This long-term investment seemingly is not too attractive to farmers. Frankly, I do not have the answer to this one. It deserves the best in all of us to find the answer.

I have said little about wildlife on the farms of the nation. I do not desire to play down its importance in the field of recreation and business. To the dirt farmer, however, it is a recreational by-product from which he gains great satisfaction and enjoyment, but little financial income.

It is my feeling that what is good for the farmer in the way of good land use and soil and water conservation, plus good production practices, is, for the most part, good for the development of most species of wildlife.

To summarize, I'm a free-enterpriser who grants that everything can't be done by free enterprise. I would point out that under our system of individual ownership, farmers have made an enormous contribution to the nation. They have been a part of an agricultural revolution. . . they are producing more and more per unit of everything. U. S. consumers pay a smaller proportion of their income for food than anywhere else in the world.

A smaller and smaller percentage of our people are making their living on the land. Right now only 15 per cent of our population are farmers. Just a little over 100 years ago this figure was 75 per cent. All this has come under a system of private enterprise.

Farmers are noted for the kids they raise. They grow up and make good, solid wholesome, useful citizens. We must preserve the conditions that make this possible. The farmer himself is known also as the great political stabilizer. His mode of life contributes to stability of thinking. He is a valuable asset to the country. Let's keep it that way.

DISCUSSION

VICE-CHAIRMAN ORDWAY: Thank you, Mr. Battles, for giving us the producers' point of view. Now, we have a chance to discuss this whole front, having had it laid before us from the various angles we have heard. Who would like to start the discussion?

MR. CHARLES STAFFER (Michigan): I would like to ask Mr. Battles this question, do you agree that the same recreational opportunities and facilities are offered by public forests as by those in private ownership?

MR. BATTLES: No, I don't. I agree that recreational areas and public hunting areas and areas for camping, boating, and that sort of thing are logically a state or a federal responsibility. I was referring to large tracts that are outside of that realm.

MR. ED RAY (Department of Conservation, Lansing, Michigan): Would you agree that the individuals should provide for them individually?

MR. BATTLES: My definition of government would be to protect the people against economic and social harm and I agree that the reason for an organization of this type is for individuals to accomplish what they are unable to accomplish alone. I am also fearful of the consequences of government in this way.

Yesterday I paid the rest of my income taxes and it jarred me considerably so my viewpoints today may be slightly different than they were Saturday night, but the tax load is a factor to consider, and I refer particularly to the tax load that goes to Washington. I have seen huge, federal programs that stagnate into inefficient monsters, actually.

Now I am granting again, we need some state and federal ownership, but I like the philosophy of private ownership wherever we can handle it with whatever regulations it takes to handle it. These big federal programs in some cases are pretty inefficient and then I like the philosophy that comes with people doing things close to home insofar as possible. Granting that the states didn't do certain things rapidly enough, but when the people at home have a say in voting the money and deciding what is going to be done, they have an interest, a feeling of responsibility that they are a part of a great democracy. I basically feel that our democracy was set up to preserve that sort of thing. Then of course, there is the danger of this increasing federal ownership, as might be conceivable at some time under either program, deteriorating into a vast vote-buying machine that places the vote of each individual on the auction block of temporary expediency. But, I agree with what you say that there are some grounds for public or state control.

MR. RAY: The problem of conservation recognizes the multiple values of natural resources. You said you wanted a minimum of regulations. I would like to know what has been done primarily by private enterprise in which the conservation achievement has multiple values.

MR. BATTLES: We may be talking about two different things. Now, I don't know where we ought to make the dividing point, but the multiple-use areas, I think, contain grounds for public ownership. I talked primarily about the broad farmlands that make up some four hundred million acres of our nation, and there, I think that good land use, which is conservation of soil and water for the most part, is profitable to the individual farmer and that we will make more progress under private enterprise when the individual farmer is in charge of his own destiny.

MR. RAY: Let me ask you a question. You can answer the same thing in the farm area also. Can the farmer who is it at a bare subsistence level do the things necessary to preserve the land or increase its value in production?

MR. BATTLES: In the long time we can. As I mentioned in my talk, we have a public obligation to help him buy a larger farm or change over into the forest and grassland type of operation that make for an efficient, economic farm unit. And some of those units are small, as you imply, at the present time. They are poor land and land that needs its fertility raised and water and soil erosion devices put on them. But, with a national philosophy and the help of the various educational research and action agencies, we have to get the job done with a new philosophy, to get it done by working as a unit. I think we can do it under public management rather than private ownership.

In such a poor area as Pike County, Ohio, where I used to make a living, some areas should be devoted to public recreation or forest production.

MR. CHESTER S. WILSON (St. Paul, Minnesota): I was impressed by the fact that while Mr. Battles seemed to be somewhat optimistic about progress in improving land use, in the next breath he pointed to the need for increased technical service by the Soil Conservation Service in assisting farmers to apply good soil conservation practices and sound land management and to that point I should like to ask him a question. But first, I should like to call attention to the fact that according to reports, in spite of all the progress that has been made in spreading soil conservation districts over the face of the country, as yet we probably do not have land management plans made for more than one farm out of five, and we were told that in actual application of soil conservation plans, there probably was not over one farm in 50 that is approaching complete good land management. And I should like to ask Mr. Battles, as a man right on the Washington firing line, how much larger improvement crew we need in the Soil Conservation Service than the present forces that are helping the farmer apply the devices on the land, and who should apply the additional forces?

MR. BATTLES: I imagine that you are right in saying that I don't know how many farms do have a soil conservation program worked out by the service with cooperation of the farmer theron. I guess we have 1,900 districts out of our 3,000 counties or more. But, we have a substantial amount of the country covered by districts.

This program is less than 20 years old, and maybe that is a pretty good progress to make in 20 years as events move in this country. I don't know what the exact figure is. I don't know if it is known on the percentage of soil decline we are having as far as productivity in concerned. Now, I am told it might run as much as two-thirds or three-fourths of 1 per cent per year in soil productivity levels. So, we know more education and added technical assistance through soil conservation services are necessary. How much extra money it will take? Quite a little. I think it should be a gradual thing. And if you will note, the appropriations have been gradually going up from the thirty millions on up to something over sixty million a year now.

We need good men in those categories, so the expense is not only in terms of men, but in the quality of men also, which gets into the Civil Service proposition. But, the education approach, the approach of technical assistance, in some areas of subsidized credit, of a philosophy with all of these agencies working towards that philosophy under a system of private ownership is to me a thing that has many advantages.

In think the Extension Service ought to get its funds raised and they are going up this year, as well as those for research and the S.C.S. Now, Extension gets funds in the lower thirty millions, S.C.S. about sixty-odd million, and for research federal appropriations are about fifty million. Add them all together, and they still don't total the A.C.P. appropriations.

MR. ALEX DZUBIN (Madison, Wisconsin): I get the impression from the discussion here that free enterprise will be all right if people get enough help from the government.

MR. BATTLES: I will have to answer that, sir. I would say this, it is our responsibility as people, to do it privately. If we can't do it privately, we need regulation. That is for sure.

We have a strangely peculiar system or free enterprise in this country under regulation which has led to the greatest standard of living mankind has ever known. Now, I have spent a good deal of time out of the country. I have spent time in Russia and a lot of time in Poland, and I have been around some. And every time I come home as a good, solid American. Now, those systems over the ages have deterioated to the degree they have under socialism or communism or whatever it is—and when you see the level of living of those people, I say, believe me, I am going to fight for the system that we have in this country and I am going to fight for it hard, for under that system we have gained what we have got. That doesn't say that we should not plan for the future, that we shouldn't plan for the wise use of our resources, and it doesn't say furthermore, that the full answer is state and public or federal ownership. (Applause)

VICE CHAIRMAN ORDWAY: We have time for one more question.

MR. RAY: I think the gentleman made the statement that our country has grown to greatness through one thing, free enterprise. That is only a half-truth. There is more to it than that. Our country was first of all, endowed with a great natural resource, the like of which is found no where else on the scale it it found here. But, with that natural resource in reserve, people in this country would never have developed it into that greatness without personal application and free enterprise. But, let's not overlook the fact it was the captial stock of the resources in the country to begin with that made the country great.

MR. BATTLES: I will agree with that.

DR. SETH GORDON: Mr. Ordway, I would like to get into this discussion with Mr. Battles a little further but the time is too late to do it. I admire a fellow who is quick on his feet and capable of handling himself when he is attacked from all directions.

This has been an exceptionally good panel, and I wish we could take the basic thinking that was laid on the table here by Professor Allen and by George Peterson and the others who have participated in the discussion this morning. But, there was an question that I was thinking of asking. And that is, why do the farm people of this country still encourage the drainage of all the potholes and swamps and participate in getting funds for that sort of encouragement when we conservationists would like to help them keep some of the natural habitat on their land, and also serve as a fine water reservoir for their own use? I am more concerned with the conservation of water from one end of the country to the other than anything else. But, as I see the nozzles of the pressure pumps and the portable sprinkler systems from one end of the country to the other, sucking the water out of every creek and every little lake to apply irrigation methods, I am wondering where we are going to wind up after a bit.

Dr. Gabrielson, former head of the Fish and Wildlife Service, now the President of this fine organization, made a reference to some of the problems that we would have to watch out for in his opening remarks. And one of them was, he was fearful that the waterfowl regulations adopted last year might have been too liberal. We, in the Far West, have been accused of asking for more liberal waterfowl regulations, and I think you folks here ought to know that what was done last year isn't going to endanger the waterfowl supply in the Far West.

The best answer to that is the fact, in the annual inventory, the guide by which we go, we find that this year, in January, we had 9,973,000 to 9,974,000, in round numbers, in ducks, geese, and brant, in the Pacific flyway, and that is quite a gain over last year. The figure for last year was 8,279,000. And there is an increase of 381,000 coots over what we had before in the figure, because more attention has been paid to the coots. But, subtract that from the total. Leave the coot increase out of the picture entirely, and you still have 9,279,000. And the State of California, where we are wintering two-thirds, let's say 60 per cent roughly of the birds, had a couple of hundred thousand more birds. I will be honest about it, about 150,000 more birds than a year ago. So, I don't think there is anything for anybody to worry about in that direction, and I am perfectly willing to trust to the good judgment of the National Flyway Council with respect to the original plans and what the U. S. Fish and Wildlife Service in the future determines on that score.

I felt in fairness to all of you, you ought to know we are not in any danger of overharvesting the waterfowl supply in the Pacific flyway.

CHAIRMAN LESAGE: Well, ladies and gentlemen, I believe we have had a very good morning and a very good discussion. The discussion was mainly on the respective merits of free enterprise and government control here in the United States. Well, it happens we have these discussion in Canada where we also believe in free enterprise. Our natural resources, like yours, are tremendous. We believe in free enterprise to develop, but we believe as strongly in government controls, be it federal or provincial, to conserve and renew them for future private enterprise. I believe that is our policy and it seems to be pretty well yours, that we should have government controls to protect, conserve and renew our resources for future private enterprise.

I wish to thank you, ladies and gentlemen, for the constant attention you have given the speakers this morning. It shows appreciation of the great value of the contribution of each and every one of them. In the name of all, I wish to congratulate you gentlemen of the panel and to thank you.

This 19th North American Wildlife Conference has had a very good beginning. We have touched upon the ethical, social, economic and political grounds all in one morning. For three days we shall have more practical studies in ownership and use of resources.

I wish, ladies and gentlemen, to thank you personally for your welcome and your cooperation this morning, and to conclude our proceedings, may I wish you in my own language, *tres bon appetit.*

GENERAL SESSIONS

Tuesday Afternoon—March 9

Chairman: Chester S. Wilson
Commissioner, Department of Conservation, St. Paul, Minnesota

Vice-Chairman: H. Dean Cochran
Regional Forester, U. S. Forest Service, Milwaukee, Wisconsin

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WATERSHED MANAGEMENT GOALS

INTRODUCTORY REMARKS

Chester S. Wilson

As those of you who know my good friend Henry Schmitz, President of the University of Washington, will appreciate, you are confronted by a substitute, and I am sure that you all share with me a keen disappointment at his inability to be here. Dr. Schmitz and I worked together for many years in conservation laboratories in Minnesota and I was looking forward to an opportunity of renewing old associations with him, but unfortunately, the pressure of important duties at home has kept him away.

Now, when I was called upon to pinch-hit here, I was told that it was the duty of the chairman to make some appropriate remarks. I don't know why that should be necessary with the array of talent we have here this afternoon, but I would like to say that like all of the rest of us, I have been very much interested in watershed problems. The presence of that subject on the program indicates that all of us are interested in it and that is just a manifestation of an even wider interest that is spread across the country.

Now, the professional or technical conservationists have been working with watershed problems for a long, long time, trying to get people to pay some attention to them, and frequently we have had voices crying in the wilderness with nobody listening.

But, now, all of a sudden, in the past few years, people have awakened to the fact that watersheds are important, and like everything else in this country, when we Americans get hold of a good idea, we are apt to overwork it. So, from what you hear around now, watersheds are in the air. And also from what you hear around, you can say that a great many ideas about watersheds are very much up in the air. It is just an indication of how we Americans are prone to be carried away with our enthusiasm for new ideas. We get some concept like this watershed management idea and we think it is going to be the cure-all for everything. But, there has been a lot of fuzzy thinking about these watershed programs and problems.

All of us who are in the game recognize there are many problems of conservation for which watershed management is not the answer, for the obvious reason that the factors involved are not governed by watershed boundaries. For example forest fire control, insect and disease control and enforcement of hunting and fishing and burning regulations. Those things pay no attention to watershed borders. But, on the other hand, there are very few conservation problems, even those I mentioned, that are not affected in some degree by what goes on in watersheds, and there are obviously some conservation problems of major importance which are largely or entirely governed by watershed forces or conditions and for which watershed management is the only effective solution.

Now, it is amazing that man did not wake up to this obvious fact before, because the human race has always lived on watersheds, and yet how little we have really known about them until lately. Fortunately, we are beginning to delve into the mysteries of watersheds and find out what makes them tick. A lot of pioneer research has been done, as you will hear from some of the speakers here this afternoon. A great deal more remains to be done. But, the widespread public interest in these watershed problems, and the fact that we are getting more and more support for watershed research and survey work, is an encouraging sign.

We have, for example, the emphasis that has been placed on watershed studies in the work and in the recent publications of the Conservation Foundation. My attention was just recently called, as I am sure happened also to others of you who keep in touch with that important agency, to some of the recent publications sponsored by the Foundation, particularly Dr. E. A. Coleman's notable work on vegetation and watershed management in which there was a very extensive bibliography that will be of great use to all students of the subject. These and other publications touch on many phases of this complex watershed situation. But, they have one thing in common. They all make it very clear that through all the ages while man has lived in watersheds, he has not been out of them. He has persisted in defying the immutable forces of nature to his own undoing, and it is about time for man to realize that watersheds are the tracts of the Almighty and the closer man picks his own course thereby, the better will be his chance of survival.

So, at this session, we are concerned with a vitally important subject. The theme is highly purposeful—"Watershed Management Goals." And certainly we need to get a clear view of what we are driving at in order to deal successfully with the watershed problems.

Now, it is a well-known fact that carpenters build houses by hitting nails on the head, not by pounding the boards. You are going to hear some nails hit squarely on the head this afternoon by some very expert nail drivers, and the lead-off man on this panel is one who is eminently quailified for that commission. I take pleasure in calling on the first speaker, Mr. D. A. Williams, Administrator of the Soil Conservation Service.

WHAT IS WATERSHED CONSERVATION?

D. A. WILLIAMS

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

I am pleased to have the opportunity to address this group which is made up of some of the most ardent conservationists in the nation You call it the North American Wildlife Conference, but we all know that most of those in attendance are concerned with much more than wildlife conservation, *per se*.

As an organization, you recognize that this country can never have an effective wildlife conservation program except by building it around adequate conservation programs for the soil, forest, range, water, and other natural resources that are inextricably tied to wildlife. Therefore, I am basing my talk on the assumption that all of us here—the foresters, the hunters, fishermen, campers, ornithologists, farmers, ranchers, engineers, range conservationists, soil conservationists, and all others—are working toward the same general objectives.

The subject assigned me, is: "What is Watershed Conservation?" It seems to me that the term "watershed conservation" is broad enough to include almost any phase of conservation. Nevertheless, I shall try to define my conception of watersheds. In doing so, however, I think you will permit me to digress somewhat and discuss briefly the small—watershed protection program that the Soil Conservation Service is now working on. I do this partly because it will be the easiest way to explain some of our concepts of watershed conservation.

WHAT IS A WATERSHED?

What is a watershed? The term largely defines itself: it is all the area that sheds water into a given stream, lake, pond, or other catchment. The greater part of most watersheds is made up of farm, grazing, or forest lands, although some may contain wild lands or badlands. Most watersheds also include towns or cities; and usually they include considerable areas devoted to roads, highways, railroads, factories, mines, and other man-made structures. And the stream, lake, or pond that serves as the catchment must be considered a part of each watershed.

Furthermore, the plant life that grows on the land forms an integral part of a watershed—the trees, grass, cultivated crops, and all other plants. And the animals that live from the plants and water—the domestic livestock, the wildlife, fish, and other animal life—constitute an important part of most watersheds.

Finally, we should bear in mind that the people who live there and use and manage all these resources are also a part of each watershed—and, by far, the most important part. After all, it is for *people* that we plan and execute a watershed conservation program.

WHAT IS CONSERVATION?

What is conservation? True conservation of natural resources does not mean hoarding them. It means wise use in such a way that the greatest immediate production or benefits will be derived without depleting the basic resources themselves. Often, the best conservation program will result in increased production and improved resources, both at the same time. That is usually what we strive for in our conservation programs.

WATERSHED CONSERVATION IS COMPREHENSIVE

If we accept these definitions of "watershed" and "conservation" then true "watershed conservation" becomes a rather comprehensive undertaking. It involves the conservation, management, and use of all soil and water and all the things that depend on them—trees, shrubs, grass crops, wildlife, fish, cultivated crops, livestock, and so on. And it includes proper construction and maintenance of roads, highways, railroads culverts, bridges, dams, and levees. Also it includes adequate protection and proper management of cities and towns and their water supplies, sewage systems, and recreational facilities. And in many instances it includes the protection and management of factories, mines, oil wells, and other industrial plants to assure adequate water supplies and a proper disposal of wastes. It may include dredging, channel improvement, or bank protection for streams. These are a few of the more obvious things that are involved in watershed conservation. There are others.

INTERDEPENDENCE OF WATERSHED RESOURCES

The way in which any one of these resources or developments is used or managed usually affects several of the others. For example, poor construction or maintenance of a road or highway may start gullying that seriously damages the crops and land of nearby farms and helps fill streams with mud that suffocates fish and contributes to floods downstream. The improper disposal of city sewage or factory waste may not only destroy much of the water life of a stream but threaten the health and recreation facilities of people downstream. Poor farming methods may lead to erosion that affects the entire economic life of a community and heightens flood crests. The improper cutting or burning of a forest may deplete or destroy the wildlife that resided there and lead to heavy siltation and floods on the streams below. Thousands of other examples might be given as to how these things affect each other, but I am sure you are fully aware of the interdependence.

It all adds up to this: A true watershed conservation program must take into account each patch of land and the plants and animals that live on it, each rivulet, pond or stream, each man-made structure, and every activity of the entire area.

FULL CONSERVATION REQUIRES 100 PER CENT PARTICIPATION

If we accept this concept of "watershed conservation" it becomes obvious that a full watershed conservation program can be carried out only if all the people who live, work, or own property there participate in the program. Of course, we will seldom get everyone to take part; but the nearer we come to getting 100 per cent participation, the nearer we will come to getting full and effective watershed conservation. That is one of the main reasons why we, in SCS, think that small watersheds are logical units on which to start conservation work. In a small watershed, of community size, we can discuss the program with practically everyone and often get almost 100 per cent participation.

OUR SMALL-WATERSHED PILOT PROGRAM

As you doubtless know, the last session of Congress appropriated 5 million dollars to start a new program in small upstream watersheds. In making the appropriation, Congress directed the Department of Agriculture to designate areas to serve as "pilot" watersheds in a cooperative program. The main purposes were to demonstrate two things: (1) the physical and economic benefits of soil and water conservation and upstream flood prevention, and (2) ways and means of providing more effective local-state-federal cooperation in planning and carrying out watershed programs.

The Soil Conservation Service was given primary responsibility by the Department for carrying out this program. Soon thereafter the SCS received scores of requests for aid from soil conservation districts, small-watershed associations, and other organizations or groups indicating their desire and ability to cooperate in the program. By the end of 1953 the Service had designated 62 small watersheds, scattered through 34 states, as pilot projects. These watersheds range in size from about 12 to several hundred square miles. In each of them some responsible local organization initiated the project and gave active sponsorship to it. In most cases, one of the sponsors was the local soil conservation district.

LOCAL PARTICIPATION ESSENTIAL FOR SUCCESS

I wish to emphasize that we consider local initiative and sponsorship of fundamental importance. And we think it essential that local people and organizations share part of the costs of these programs. These are not federal works programs, in which the Federal Government does all the planning and bears all costs. They are cooperative undertakings.

Our previous experience in land and water conservation work convinces us that the effectiveness of watershed treatment is in almost exact proportion to the interest and activity of local people and organizations. This has been so true that we consider it not worthwhile for the Federal Government to undertake a watershed conservation program without active sponsorship and cost sharing by local interests.

COOPERATIVE WORK PLANS

Work plan preparation was started on each of these 62 small watersheds as soon as it was approved for operations. This was a cooperative job between officials of the local sponsoring agency and planning specialists of SCS, and in some cases the Forest Service.

The sponsoring agencies invited other local and state agencies to help in planning the programs. County officials, including the county agent, were invited to participate. Cities, towns, sportsmen's clubs, chambers of commerce, vocational agriculture instructors, industrial organizations, drainage districts, irrigation districts, state extension service, state conservation departments, state highway departments, and many other types of organizations are cooperating in these projects. And, of course, the local soil conservation districts are always active participants.

The SCS expects to coordinate its efforts with those of other federal agencies, such as the Corps of Engineers, Bureau of Reclamation, Bureau of Land Management, and Fish and Wildlife Service, where their interests are in any way involved. Agreements have been made with the Geological Survey and Weather Bureau for assistance in evaluating the effectiveness of the programs.

We hope that the work plans for all of the 62 small watersheds will be completed by June of this year.

We are trying to make these pilot watersheds truly cooperative enterprises between all local, state, and federal interests concerned. That is one of the strongest arguments for these projects. By getting active interest and help from all people and agencies we think we have a good chance of achieving true watershed conservation.

WILDLIFE CONSERVATION CONSIDERED

I wish to point out, to you who are primarily concerned about wildlife, that these pilot watersheds offer excellent opportunities for local wildlife organizations to participate in planning and carrying out measures that will promote more and better wildlife.

If you live in or near one of these watersheds and have some constructive ideas about how to better integrate wildlife conservation with soil conservation and flood prevention, you should offer your advice and services to the local sponsoring agency. In this way, you can help plan and carry out these watershed conservation programs. You can help in seeing to it that adequate provisions are made for conserving and improving beneficial wildlife.

In a few instances there have appeared to be conflicts between wildlife and farming interests, especially where land drainage was involved. You will find that SCS technicians always consider wildlife aspects before recommending the drainage of farm lands. They are anxious to confer with any interested wildlife organization in helping plan these watersheds, or any other projects.

And, may I suggest that it is not enough for wildlife conservationists merely to oppose drainage projects that appear to them to be unsound or untimely. A more positive approach is needed. First they should gain a thorough understanding of the facts, the objectives and the expected results in each particular area. Then, constructive suggestions or alternative proposals can usually be made that will get better results than uninformed opposition.

Can not some way be found whereby the large number of enthusiastic wildlife conservationists can join hands with farmers to accomplish more real conservation for both land and wildlife?

I believe that can be done. But I think that farmers and wildlife conservationists are going to have to sit down together and work out solutions for these problems. Each case may be different, and each may require a different solution. I'm confident there can always be a satisfactory solution.

LAND TREATMENT IS FUNDAMENTAL

Plans for the small watersheds in the new program place primary emphasis on land treatment. They call for full conservation treatment of all farm, grazing, forest, and other lands, including lands devoted primarily to wildlife.

It is not necessary for me to go into details of land treatment. I am sure that Mr. Kirk Fox will adequately cover this subject when he discusses "The Place of Soil Conservation in Watershed Management." But I do wish to stress that land treatment is absolutely essential for effective watershed conservation. We believe this so firmly that SCS does not think it wise in most cases to undertake other works of improvement on a watershed until we are assured that most of the land will receive adequate conservation treatment. Nevertheless, we know that other things are necessary to get true watershed conservation.

WATER RETARDING AND CONTROL STRUCTURES

Since flood prevention was designed by Congress as one of the major objectives of these pilot watershed projects, the plans have provided for as much protection against flood and sediment damage as seemed feasible. We recognize that land treatment, alone, will not prevent floods and flood damage during periods of heavy and persistent rainfall. It must be supplemented by, or combined with, waterflow retarding structures. channel improvements, and other water-management structures.

The water-management structures may be small dams to detain flood water temporarily; or they may be sediment traps, gully stabilization structures, large diversions, stream channel improvements, drop inlets, and other types of water control devices. Each structure is designed to do the specific job at hand, and all structures are fitted into the land treatment measures and the over-all watershed program. This, in brief, is the type of program that is being developed for each of these small watersheds.

COST-SHARING IN EXECUTION OF PROGRAM

This program is carried out somewhat as follows on most watersheds: The individual farmers, ranchers, and landowners do the normally needed soil conservation work on their lands, with technical aid from SCS technicians.

Where water-control structures that will affect more than one farm are needed, the Federal Government will usually bear 50 per cent or more of the cost of construction. Local organizations or people will be expected to furnish all easements and rights-of-way and assume responsibility for maintenance of the structures. Other problems are to be met in a similar cooperative manner on a cost-sharing basis.

A condition to providing federal assistance in this pilot watershed program is that the benefits must exceed the costs. Therefore, we make careful economic studies in the course of developing work plans for each watershed. All of the independent measures, such as floodwater retarding structures and channel improvements, are justified on the basis of the benefits they, alone, provide.

PROGRESS ON WORKS OF IMPROVEMENT

Immediately after designation of each watershed we sent additional technicians to help speed up application of conservation practices to the land.

In the meantime, our engineers were completing designs for many of the water-retarding structures and stream-channel improvements where obviously needed. Contracts are now being let to private contractors for construction of these works of improvement.

Because of necessary delays for drawing up plans and designs, construction work will not get underway on a large scale until this spring. It can then move ahead as rapidly as available funds permit. We think that the treatment of these 62 small watersheds should be completed in about 5 years at a cost of about 29 million dollars to the Federal Government and an approximately equal cost to local interests.

SOME LIMITATIONS OF THE PILOT WATERSHED PROGRAM

At this time I should like to point out that we do not think that these small watershed projects will give us all the answers to our watershed problems. This is true for two reasons: (1) both the authority given SCS and the objectives defined by Congress were limited, and (2) these are small watersheds that do not deal with downstream problems on major rivers.

The primary objectives set forth were: to conserve soil and water, and to alleviate upstream damages from floods and siltation. No authority was granted SCS to construct large multi-purpose dams, control stream pollution, develop recreational facilities, etc. Furthermore, we do not deem it feasible to try to eliminate all upstream floods.

Our experience has shown that it is economically feasible to prevent more than 90 per cent of the flood damage along most creeks. It has also shown that it is seldom practical to prevent all flood damage, especially that from the large, infrequent floods.

On most creeks more than 90 per cent of the damage comes from floods that occur frequently—from small floods that occur one or more times each year to larger floods that occur once every 10 to 25 years. Less than 10 per cent of the damage comes from the spectacular floods that occur only once every 50 to 100 years. Structures designed to prevent damage from floods of 10 to 25 years' frequency can be built smaller and at much less cost than those designed to prevent any damage from the super-floods. And the structures that will safely handle the 10 to 25 year frequency floods will eliminate much of the damage from the super-floods.

DOWNSTREAM WATERSHED CONSERVATION MEASURES

I think most of us are agreed that watershed conservation should start at the headwaters, except where special, urgent downstream problems are involved. But I am sure we all know that watershed conservation should not stop at the headwaters. It should continue downstream until the water reaches the sea. Downstream measures are essential on most major rivers for flood protection, navigation, hydro-electric power, water storage, anti-pollution, and other purposes.

In our upstream work, the SCS tries to develop a program that will fit in with any downstream work done by other agencies or groups. As I stated, we always consult with the Corps of Engineers, the Bureau of Reclamation, or any other interests, public or private, that contemplate the construction of large dams below the small watersheds on which we work. We also consult with agencies, corporations, or individuals involved in any other type of watershed improvement. By doing this, we expect that such upstream work as we are now doing will not need revision as complete river basin programs are developed.

THE NEED FOR WATERSHED RESEARCH

Before concluding, I should like to say a few words about our need for research on watershed problems.

Of course, the need for research to find better ways of doing things will never end. But in addition to the normal research on agricultural, hydrological, sedimentation, and biological problems, I think we urgently need more study on the relationships between upstream treatment of small watersheds and downstream treatment of major rivers.

For example, we do not know just how much effect the treatment of many small watersheds in a river basin will have in lowering flood crests on the main river. We have ample reasons to believe that if all small watersheds in a river basin were so treated that downstream floods would be much less serious; but we do not know exactly how much the flood crests would be decreased.

I think that we should have more cooperative study, on this and similar problems.

OTHER PHASES OF WATERSHED CONSERVATION

You will note that I have not attempted to discuss details of any phase of watershed conservation except the upstream flood prevention aspect. These other aspects, some of which I pointed out early in my talk, are extremely important in a complete watershed program. I have refrained from putting more emphasis on them knowing that they will be discussed by those who follow me on this program.

Again, I say that I am pleased to have had this opportunity to be with you here in this great meeting.

DISCUSSION

VICE-CHAIRMAN COCHRAN: Mr. Williams in his very interesting paper has directed our attention to two very fundamental natural resources, namely soil and water, as to whose responsibility, he says, full watershed conservation requires the participation of all people who live, work or own property in watersheds. As I think about our general world-wide situation, it occurs to me that most of us live in some watershed, so I think we can be sure that Mr. Williams is not ignoring any of us in this discussion of whose responsibility the soil and water resources are.

One observation on Mr. Williams' definition of watershed conservation; it seems to me very appropriate that the terms in which he discussed watershed conservation are essentially equivalent to watershed management and that places the subject on a very sound, practical basis.

In discussing the topic of this meeting, "Watershed Management Goals," Mr. Williams has focused our attention more narrowly on the small watersheds which constitute one of the outstanding current developments in watershed management, and in doing so, set the goals for those to demonstrate first, physical and economic benefits of watershed management, and second, to demonstrate more effective local, state, and federal cooperation. These small-watershed demonstrations, according to Mr. Williams, will not provide solutions for all of our watershed problems, but it is appropriate here that they should be discussed, since they are more closely related to the interests of wildlife conservation than perhaps any other aspects of the watershed conservation subject.

Mr. Williams points out that this program, the small watershed program, provides an excellent opportunity for the promotion of wildlife, an opportunity for local wildlife organizations of one kind or another, and the suggestion that they get into the program and participate actively in it.

I believe that what Mr. Williams has said about the relation of these small watersheds to the promotion of watershed interests is significant.

Are there any questions on this paper, either the specific questions I have suggested or others that are raised in connection with the presentation?

DR. JOSEPH PETTUS (Jackson, Mississippi): He referred to the Mississippi Basin. I think he was down in Vicksburg not long ago. We would like to call attention to the fact that the U. S. Engineers are not taking into consideration our wildlife like they should. I have been agitating that down in Mississippi for a couple of years and I think I have been informed to the extent that I know what I am talking about. The Engineers are anxious to work with us, but they don't know what they need. They are beginning to work on the Yazoo Basin and dry up some of our good duck and white perch holes. They want to do that. We want to call attention to the fact we need more cooperation and better understanding with the U. S. Engineers on flood control, and that has to do with watershed conservation also.

MR. WILLIAMS: I concur wholeheartedly in your statement. I think there is a very great need for further recognition not only on the part of the Corps of Engineers, but all federal agencies with any type of work improvement programs that they may be responsible for. I believe there is only one correct answer to that kind of a problem and that is, control of these programs in the hands of the local people, rather than in the hands of the bureaucrats.

MR. DOUGLAS WADE (Columbia, South Carolina): I want to bear right down on one local watershed in South Carolina, because I think it will illustrate some points that need clarification at this time. I refer to the Twelve Mile Watershed, which is one of the 50 pilot watersheds selected for intensive study throughout the country. In the last year the Clemson College has been called on to engage in an early program on this watershed. I mention that college because it is an agricultural institution and the teachers in the local counties affected by the watershed, likewise, were ignored in the early stages of the planning and to date, as far as I know, none of the educational interests in this locality have been engaged in the early planning.

Now, this early planning stage is very important in order to get full cooperation on the watershed. The Corps of Engineers will come up with a final, complete plan and will throw it at you. I would hate very much to see these pilot watersheds in the same situation, and I would like to emphasize that point, because there the local people will have to get up off their hind legs and get going in this cooperative enterprise.

You can't wait for the S.C.S. or any of the other agencies on the initial plan, to extend the invitation, simply because the invitation has not been extended too fully, so in order to get in there, I would advise very strongly that if any state has a pilot watershed plan, to get up yourselves and get in there and help out. In that way, the full cooperation that Mr. Williams speaks of will be effected.

MR. WILLIAMS: I certainly don't disagree with you on that, either. I think that that is a must, and I can't recite the details of each one of these patricular situations. I can assure you that I have personally talked to Dr. Poole, President of Clemson, about it. I don't know if we can anticipate all the interest we have, but I am sure that the working plan is up to the point where the State of South Carolina as well as the educational institution thereof, may have a voice in the program, and certainly with respect to carrying it out. Certainly it is the local people's program, not a federal one, and it has just got to be that way. It won't work any other way. So, I am very interested to see that a lot of us recognize the fundamental ingredients to the end product.

MR. WADE: That is very true, sir, and I agree with you 100 per cent. The point I am trying to get across is that it is cooperation and it takes cooperation on the part of the other folks besides those initially responsible for the watershed.

MR. WILLIAMS: Absolutely.

VICE-CHAIRMAN COCHRAN: I think one of the important points Mr. Williams brought out is it takes not only cooperation on the part of the local people, but perhaps initiative also, as this gentleman has brought out, to make these programs successful.

THE PLACE OF FOREST AND RANGE IN WATERSHED CONSERVATION

H. G. WILM

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During the early years of the conservation movement in the United States, great emphasis was placed upon watershed problems that were being created by the progressive cutting, burning, and grazing of forest and range lands. Ever since Gifford Pinchot's crusade for conservation, the proponents of this viewpoint have maintained that the mismanagement or denudation of forest and range land has meant increased floods, erosion, and sedimentation on one hand; and aggravated drought conditions on the other, along with the drying up of springs and streams.

The expression of these strong viewpoints inevitably led to the growth of an opposing school of thought, spearheaded to a large extent by the engineering profession (Hoyt and Troxell). As might be expected, this group established the view that forest and range vegetation has little effect on the behavior of streams. As a result, a series of professional conflicts developed during the first several decades of this century. More profitably, the differences of opinion inspired a number of research projects designed to find out the real effects of vegetation and land management upon watershed conditions. This research has accumulated a substantial body of knowledge, and has helped compromise many conflicting viewpoints. Now the opposing schools of thought are relatively close together in their understanding of these relationships.

In recent years another set of concepts has developed, which again places special emphasis on the virtues of upstream watershed improvement in the control and management of water. In principle this line of thinking is sound. As sometimes expressed, however, it overemphasizes the value of upstream engineering work and cropland improvement, and tends to minimize the importance of forest and range vegetation and its management.

The purpose of this paper is to express, from the viewpoint of my own experience, the real place of forest and range management in watershed conservation, as contrasted to farm-land management, land drainage, and upstream engineering structures. My thesis will be that forest and range management has an important influence on watershed conditions which should not be underemphasized; that cropland management exerts its principal effects on soil stability rather than streamflow regulation; and that the effects of upstream engineering works, including land drainage, are ordinarily local in nature and not always beneficial.

THE SITUATION

When the pioneers started to penetrate our continent from the Atlantic coast, most of the eastern United States was covered with forests. In general it is safe to say that no flood problems existed, for two reasons. First, the uplands were in good shape so that little surface runoff and erosion occurred, and the smaller streams must have been well stabilized. Second, the rich bottom lands of our eastern rivers were not occupied by farms, villages, or cities; so that no damage resulted even when high water did occur.

As our people moved westward, however, they cleared great areas of the natural forest, converting them to pasture and cropland. As a result only half of the original area is still in forest; and the remaining forest has been largely cut over, grazed, and burned, so that it is in relatively bad condition. On the other half, clearing and subsequent cropping inevitably reduced the capacity of the soil to take in water. The result has been accelerated surface runoff and erosion, and flashier, muddy floodcrests in the streams.

This condition still exists on large areas; it is an inescapable consequence of converting land to crops. The repeated tilling of land and its exposure to the impacts of rain, and the grazing and trampling of pasture land necessarily mean increased rates of runoff and erosion as compared to forest land in good condition.

As our people moved farther westward they found great expanses of prairies and plains and mountains untouched by white man's exploitation. Some of these lands have always been characterized by high rates of runoff and erosion: the "badlands" of Wyoming and South Dakota, and semi-desert areas like those of the Colorado River tributaries in Arizona. Also, it is likely that the Great Plains were repeatedly overgrazed by the migrating herds of bison, as well as by other western game. The records of early explorers indicate many of the typical symptoms of overgrazing in this belt of land. But most of the mountain lands of the Rockies, Sierra Nevada, and Cascades can be considered to have been in relatively good condition, with well-controlled streams.

As in the East, in many places in the West these conditions have been markedly changed by the overcutting of timber, overgrazing of range by domestic livestock, and the poor management of game populations. As a result, many western mountain streams exhibit the typical characteristics of unhealthy watersheds.

On the Great Plains the bison herds have been replaced by concentrations of domestic livestock. These have perpetuated the conditions created by the game populations: eroding areas of thin shortgrass vegetation, interspersed with cactus and tumbleweed. And capping even these conditions has been the cropping of areas in the "Dust Bowl," which should never have been cleared of their grassland cover.

While the western mountains and plains were being exploited during this past century, the valley areas within reach of the great western rivers have been progressively developed into rich, productive irrigated cropland. At the same time, the presence of these streams has made possible the growth of towns, cities, and industries. This has meant a progressively intensifying demand for water, until now water needs exceed available supplies in many areas in the West.

POSSIBLE REMEDIES

This is the present situation, outlined in a sketchy way. And what are the remedies? Can watershed conditions be improved by better management of croplands, by the use of engineering structures to store and control water, or through better forest and range management? Which of these three main courses of action can be expected to yield the best results?

The Role of Croplands. Let us first touch briefly upon the possibilities in cropland management. This has been the dominant feature of the agricultural conservation movement. In many parts of the United States, great forward strides have been accomplished through technical assistance, education and other aids, to help farmers adopt sound techniques for soil conservation. Improvements in land condition have been accomplished through contour farming, terracing, the stabilizing of waterways, land-use changes from row crops to close-growing crops and grasslands, and other activities pointed at stabilizing the soil and retarding runoff. Their actual and probable effects have been outlined repeatedly in flood-control survey reports made by the Department of Agriculture on critical areas throughout the United

States (Lasson *et al.*). Here is a significant feature of these reports: They seldom claim appreciable flood reductions from improvement work on cultivated lands. Quite consistently, the only major benefits claimed for this work have been reductions of soil movement and increases in crop returns to the farmer. Of course such influences are extremely important. Among other things, less erosion means clearer streams and better habitats for aquatic wildlife. But if the flood-survey findings are even reasonably accurate, we cannot expect cropland improvement to have any substantial effect upon the regimen of flood-producing streams.

On a logical basis I might suggest two outstanding exceptions to these conclusions. On one hand, certainly the establishment of deep-rooted perennial vegetation and its light or moderate use can be expected to have pronounced effects upon the capacity of the soil to take in and store water, and therefore upon the runoff of streams. Second, the dissection of water-logged areas with drainage ditches and canals must certainly have a definite effect upon runoff regimen. In some cases drainage work may be expected to benefit the flood situation. More often its effect is doubtful; it may even make the situation worse. Natural swamps and bottomland forests serve as retarding basins, slowing down the rates of runoff from watershed land. But the establishment of drainage systems may effectively break up these basins, so that runoff into streams is accelerated rather than retarded. While such drainage creates new cropland it also destroys wildlife habitats; and it may not help solve flood problems.

The Role of Upstream Engineering Works. Judging from the above analysis, adequate runoff control from croplands can only be achieved with the aid of structural works: small detention and retention dams, gully-control structures, lined channels, and similar measures. In this discussion it is not appropriate to analyze the comparative virtues of upstream engineering and large downstream structures in the control and management of water. Many hydrologists now acknowledge that major downstream works are required to control big floods on the big rivers; and that upstream systems of smaller engineering works do not need to compete in this sphere. Upstream land management and engineering have a sufficiently important role in ameliorating bad watershed conditions on the large areas above the big channel structures. But it may be worth while to suggest where upstream structures fit into the whole picture of watershed management, and the effects which they may be expected to have.

These effects are well symbolized by the fact that they are installed below small watersheds—small, that is, compared to the major streams and watersheds of the country. Any upstream flood detention dam may be expected to exert its most pronounced effect upon the stream immediately below the structure, down to its junction with the next stream below. From that point on, any continuing effect depends upon the behavior of the stream which joins it. If that stream also contains a dam and if, by some hydrologic coincidence, the reduced crests from the two streams reach the junction simultaneously; only then can the effects of these dams be expected to continue undiminished down to the next stream junction. This reasoning is oversimplified, but rational. If it is carried further, it seems evident that the hydrologic benefit of a system of small structures would become progressively smaller as one moves further downstream, where the discharges from more and more tributaries are combined into the larger streams. Therefore, as suggested before, upstream engineering structures can be expected to exert their main influence in the smaller watersheds—and more especially for the smaller floods.

As a related point, upstream dams might be expected to give the most pronounced benefit in semi-arid regions such as the Great Plains, where short, local "cloudburst" floods are common. But at the same time these structures may also introduce a negative effect. Studies by the Geological Survey in Wyoming indicate that losses of water by evaporation and seepage from small reservoirs may have an important impact upon the amount of water available under legally established water rights (Culler and Peterson). This problem deserves serious consideration.

The Role of Forest and Range Land. A growing body of information indicates that the handling of forest and range lands may have pronounced effects on the volume and distribution of stream flow as well as on the stability of watershed soil and the production of sediment. The amount of character of these effects depend upon the type of forest or range vegetation, on the regional climate, and on the character and hydrologic depth of the soil mantle (Lassen *et al.*). Generally, a forest cover in good condition means a porous, stable soil and the development of maximum storage capacity for water. In many cases, measured infiltration capacities of well-developed forest soil have been higher than any expected rates of storm precipitation.

Accordingly, surface runoff would seldom be expected from a well-stocked forest stand in good condition. On the other hand, deterioration of such a stand by poorly planned cutting, skid-trail erosion, fire, or grazing has a consistently bad effect on soil porosity and storage capacity.

All of this means that the establishment or maintenance of forest cover in good condition may be expected to have a pronounced effect upon the amounts of storm water that can be taken into the soil. Whether or not these good conditions are reflected in lower flood discharges or improvements in the perennial flow of streams depends upon the hydrologic depth of the soil mantle, and on the regional climate. In areas of shallow soil over impervious substrata, as in parts of the Northeast or the Ozarks, the beneficial effects of good forest soil are minimized by rapid return of the infiltrated water to the streams. This is simply because, even under the best conditions, the shallow soil has inadequate storage capacity. At the other extreme, the most impressive effects of forest and range exploitation or good management may be expected in areas like the front range of the Rocky Mountains, where the immature granitic soils and rocky substrata are deeply weathered and rates of storm rainfall are relatively high. Another example is the "San Gabriel Complex" of the Southern California mountains, where the parent rock is very deeply fractured. There the storage capacity of the watershed is ample to regulate most floods, as long as soil infiltration capacities are maintained by a good cover of vegetation. But destructive floods and sedimentation invariably occur after the native chaparral has been destroyed by fire.

In one sense, forest and range vegetation has much the same limitations as described above for small upstream structures. In general, the most pronounced effects may be expected on the smaller streams and for the shorter, sharper floods; and also, in areas where maximum storage opportunities exist.

At this point westerners—and many easterners too—may be wondering what effect the management of forest and range lands may have on water yields as well as on flood discharges. When a dense forest cover creates maximum storage capacity in the soil through its consumption of water, obviously this means a smaller total volume of water for streamflow. In considering these conflicting problems, the land manager must look at the comparative values involved: the need for water, as compared to the need for soil stability and smaller floods. In many cases he will accept any necessary sacrifices in total volume of water, so that the water that he does get will be clear and uncontaminated with sediment. In some areas, on the other hand, where soil stabilization problems are small and floods present no important hazard, the land manager may often find it possible to manipulate his forest vegetation so as to reduce the consumption of water by vegetation and thereby to increase yields (Wilm and Dunford).

Interestingly, there are large areas of western range lands where the protection or exploitation of the vegetation greatly influences erosion, but is not likely to exert much effect on water yields (Dorroh). These are the arid lands where annual precipitation and stream runoff are low, although cloudburst rains may often occur. With high temperatures and low humidities, all available soil water is used—whether by a cover of vegetation or by evaporation from a bare soil. In such areas it is obviously advisable to build up the plant cover as well as possible, and thereby to reduce erosion rates.

CONCLUSIONS

In these discussions a number of inferences have been drawn as to the effects of different management techniques on watershed conditions. Although based on observation and research, any inferences are necessarily subjective and open to further inquiry. To facilitate such scrutiny, they are summarized below:

1. The regulation and management of water and soil on any watershed must be based on a balanced combination of several techniques: the sound management of forest and range land as well as cropland; and the use of upstream engineering works to supplement land management.
2. In general, the application of soil-conservation techniques to cropland provides major benefits in soil stability and crop improvement. These techniques have not been considered to provide substantial changes in the magnitude of floods.
3. Small upstream engineering structures have a definite place in watershed management and protection. They ordinarily exert their principal effects on the smaller watersheds and smaller floods.
4. The drainage of waterlogged land areas, especially swampland and forests, can hardly be expected to contribute substantial benefits in flood reduction. In some cases land drainage may actually make problems worse.
5. Forest and range vegetation in good condition generally builds better watershed soil conditions than any kind of cultivated crop except deep-rooted lightly used perennials. Also, forest and range vegetation occupies major land areas over a large part of the United States. For these reasons the management of forest and range lands offers special promise for the solution of watershed problems.
6. On the other hand, the management of forest and range vegetation is subject to much the same limitations as upstream engineering measures. Its predominant effectiveness is on the smaller watersheds and for the shorter, more abrupt storms; especially on areas where there is ample opportunity for storage of water in the soil.

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DISCUSSION

VICE-CHAIRMAN COCHRAN: Dean Wilm has tackled a subject that has some controversial points in it, points that have been controversial since watershed management and conservation were first attacked and considered. He has attacked these questions with great courage and skill, and probably has stirred up some questions which you would like to discuss now.

DR. WALTER P. TAYLOR (Claremont, California): I don't suppose any of us would object or gainsay the argument that the local community should assume greater responsibility for watershed conservation, but I would like to call attention to an instance where the interest of the local community is not quite sufficient. In our Los Angeles County, California, we have a population of 4,800,000 people, which is reportedly a total greater than in 19 states. We are dependent for water not only on the national forests about Los Angeles, the San Gabriel Range, but on watersheds in Arizona, New Mexico, Nevada, Utah and Colorado; so there must be a measure of responsibility for watersheds clear outside of our particular local watersheds on the part of us in Southern California in order that we water-using citizens there, might have the water needed for domestic use.

While it is highly desirable to emphasize the responsibility of use locally, nevertheless, there are many similar instances. Recently in the D'Ewart Bill, there was supposed to be turned over to 20,000 stockmen, as estimated in the New York *Times*, resources that affect not only all our people in Los Angeles County, but probably some twenty million people in the vicinity of national forests in the Far West.

It seems to me the individual resident of a watershed not only should assume responsibility in matters of this sort, but every citizen of the country should assume full responsibility for the proper handling of the watershed problem all over the country.

MR. COCHRAN: These comments bring out forcibly a statement made previously that watershed problems do not recognize state lines, county lines and other artificial barriers. They are a problem of wider regions and of the nation as a whole.

THE PLACE OF SOIL CONSERVATION IN WATERSHED MANAGEMENT

KIRK FOX

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Before stating the viewpoint of a Midwesterner concerned first with agriculture, let me define basic terms in my paper so we all know what I am talking about. A river basin includes the area from the river's mouth to the origin of its tributaries. Within that basin there may be actually several hundred watersheds and thousands of sub-watersheds. However, the entire basin is considered a watershed. The line of definition between the latter two has not been drawn if my investigation has been thorough. A watershed may range from 100 to 400 square miles. I think it would be better to call the areas now being set up for demonstration *sub-watersheds,* since they may be as small as 12 square miles. Misguided conservation enthusiasts have been critical of my position at times because I could see that, through lack of definitions, they were promoting a project too large and unwieldy to manage under present limitations of law and public interest.

In the flat or rolling lands which make up the major part of the agricultural Midwest, the best illustration of a river basin of a size convenient for study is the Des Moines, composed of 14,540 square miles, or 23 per cent of the land area of the state. From its mouth in the most southeastern county, it drains one county in Missouri, 39 counties in Iowa and seven counties in southwestern Minnesota. Within this area reside 2,612,598 people, 53 per cent rural and 47 per cent urban. During the flood year of 1947, this river below its principal tributary transported six million tons of sediment. Obviously, a successful attack on such a giant would seem possible only by completing the control of sub-watersheds and watersheds first. For all those whose interest I have aroused, I recommend careful reading of the report on the Des Moines River Basin just published by the Iowa Natural Resources Council. I shall return to an examination of watersheds after briefly defining soil conservation and its place in their management.

From the agricultural point of view, soil conservation means simply how to obtain maximum use according to soil capabilities while maintaining or improving the resource. This applies to the soil and not to its fertility, although the two are closely interrelated. Maximum use of the soil means more to the better farmers, who are in the majority, than merely top crop production, if I am an acute observer. Conservation of soil means that their stock ponds are not filled with silt, that their favorite fishing streams are not ruined by flash floods, mud and sandbars. That some of their best bottom land is not subject to overflow. It means to these farmers also that certain acres can never be tilled safely or profitably. Hence, they make of them wildlife retreats. Their boys like to make a few dollars every winter trapping muskrats, and they know a certain depth of ponds must be maintained if the' rat colony is to thrive and get enough food. The farmers appreciate the good work done by a covey of quails and flocks of song birds. They may gripe over the corn eaten by the pheasants, but they admire their cocky splendor and spirit.

Like the farmers, I maintain we must all look upon the soil as the very basis of life—plant, animal, fish, insects, and birds. Just as it gives life, it can also destroy. Carried by wild waters, it will ruin all hope of aquatic life and overwhelm with silt the nesting places of ground birds and the burrows of wild animals. And as it destroys other desirable elements in the watershed, it, too, is destroyed. So soil conservation must be the foundation of watershed management. Manage the soil and you need be less concerned about the management of water.

While I speak from the viewpoint of farmers, like them I am fully aware of the numerous and complex demands placed by society on a typical watershed. And quite arbitrarily I am thinking in terms of 100 to 400 square miles. For a sub-watershed less, perhaps 12 to 100 square miles. The Salt-Wahoo watershed in the vicinity of Lincoln, Nebraska, illustrates my point very well. In this area urban people see splendid opportunities for development of recreational facilities needed more and more by Lincoln. Likewise, they see the opportunity to get double returns on their investment by alleviating at least a part of the flood nuisance suffered by the city. Farmers see urban aid in their 20-year struggle to protect the soil on their farms. More than their individual efforts is necessary to complete the job. Actually, only a small portion of the basin formed by these two creeks is scheduled for development. Its intelligent development and management even on a limited scale will, to a large degree, provide recreation and reduce flood threats to the city. This point is emphasized that all may see more clearly the vastness of entire stream basin management to which we must eventually come.

Now comes congressional authorization with adequate appropriations to set up 62 pilot tests of complete watershed management. You have had this phase ably explained today by Mr. D. A. Williams. For me it is enough to say we have now provided in these watershed projects what I consider high school courses for those who have mastered the grades in soil conservation. For 20 years organized soil conservation work as a federal service has been under way. Most agricultural states have 100 per cent of the land area organized into legal soil conservation districts. There comes a time when the co-operators in these districts can go no further until aided by other groups. Organization of a soil conservation district, usually along county lines, does not mean all the land in the district is under actual conservation practice. Relatively few acres are so operated in many districts. But as the work includes up to 65 to 80 per cent of the area, problems are faced which cannot be solved under our present setup. Large dams and other necessary structures within a watershed cost more than present authorized sources of funds. Dam sites may involve many acres of good land. Someone must buy or donate such areas. In the Salt-Wahoo area I am told interested farmers will donate such land in order to save federal appropriations for structures. Doubtless, the Tuttle Creek watershed in Kansas may be aided by public generosity.

I am firmly convinced there are great possibilities in complete watershed development. However, we dare not relax our work in the grade school of soil conservation, the soil conservation district. It is the soil which must ever remain the foundation of watershed management—and Midwest soil is owned by the farmers. Until a high degree of interest is developed in an area so that 65 per cent or more of the acres are under some soil conservation practice, I doubt if the final step to complete watershed management can be successful. A joint study of the farm management and budgeting aspects of small watershed areas will be undertaken immediately by the Kansas State College and the economics branch of the agricultural research service. The project will be developed in Kansas. There is yet a great deal to be learned about farm management changes when a major portion of a farm is operated on a conservation basis. It would be a grievous mistake to assume the past 20 years of work had taught us all we must know to operate a farm profitably under full conservation management.

I have digressed from my assigned topic of soil because I believe so strongly in the need for clear understanding of the magnitude of watershed management. I am fully in accord with the pilot program. It's a beginning of bigger and bigger work so I want to see each step a firm and sure one. Great problems must be worked out.

Soil management in a watershed is a program including the use of each piece of land within its capability and applying the practices needed to prevent erosion and make more water seep into the soil. These practices are improved rotations, soil treatments, contouring, strip cropping, grassed waterways, tree planting, and pasture improvement. They must add up to a practical, profitable method of operating a farm. But after all these practices are generally established, I know there will be runoff water from heavy rains and when the soil is frozen. This I regard as a farm waste, for in a few months that surplus will be needed most years. If stored near its source, I can see it being effectively used in irrigation, a practice in which there is now widespread interest in the humid areas. It has proved economically sound but we lack sources of water. The small earthen dam that will impound two acres of water will be a money-maker for thousands of future farmers as it has already proved.

I am not so unfamiliar with flood problems that I offer sub-watershed management as the only needed control measure. I do consider it the first step, with proper soil management the basic consideration. Soil is essential for life.

DISCUSSION

VICE-CHAIRMAN COCHRAN: Our Chairman said at the beginning of our program this afternoon that some of the questions of watershed conservation have been very much up in the air and some of them are still up in the air. I think Mr. Fox has done a good job of bringing some of these down to earth. He not only talked about the constructive side of watershed conservation and what can be accomplished through it, but of the furious cruelty with which a watershed can strike back if abused.

Are there any comments on Mr. Fox's paper?

MR. KENNETH M. MAYALL (Toronto, Canada): Since the classic investigation by Mr. Zon in his report called, "Forest and Soil in the Light of Scientific Investigation", there have been a large number of experimental developments by the Soil Conservation Services and similar organizations, federal and state both in Canada and the United States.

All I wish to say is that in my opinion, the relation between forests and runoff, has not been given the same attention in any way as to relation between agricultural land and runoff. Apart from one or two experiments which have been mentioned, the Wagner experiment and one or two you may know, it is almost impossible to find such experimental data, and we have just heard a statement that it is necessary to get down to earth and I think that we can't get down to earth unless we have this fundamental data.

I suggest there should be a much more and greater emphasis on measuring caremully the effects of forests on runoffs and by the I mean the different effects of a young forest, a bushy forest and a mature forest on runoff, both in spring and in summer, and I think there should be a great deal more emphasis placed on this than there has been in relation to the agricultural farm.

VICE-CHAIRMAN COCHRAN: I think those in the Forest Commission could take these comments very much to heart. Would you like to comment, Dr. Wilm?

DR. WILM: As you can imagine, I appreciate these comments very much, having been in forest management research for the last 20 years, and I have felt continually the need for more facilities and more data on forest influences.

I might comment for the gentleman's information, we do have a little more, not nearly adequate, I admit, but more in the way of watershed research than he has been aware of. The Forest Service, for example, has had since 1935, I believe, an experimental forest, the Hydrologic Laboratory, in North Carolina in the Southern Appalachian Mountains, where the water effects and forest effects on streams now have been studied. A corresponding laboratory was established about the same time in Southern California, and a little later, an intensive study of comparable forests on stream flow water yield and other factors in the high Rocky Mountains of Colorado. Smaller installations of similar nature have been installed at various points in the United States.

I fully agree from my knowledge of this research that it is not yet adequate to answer all the problems involved in the management of forests and range lands, water yield, flood control or soil stabilization.

VICE-CHAIRMAN COCHRAN: Thank you very much, Dr. Wilm. Are there any other comments or questions?

DR. M. M. HARGRAVES (Rochester, Minnesota): I would like to make one comment on Mr. Fox's paper. First, I would like to say, being from Rochester, Minnesota, I am a hillbilly. I have a little farm in Southeastern Minnesota. I am just afraid from the discussions this afternoon we are getting lost on watersheds that are too large and perhaps discouraging many of the younger men in the audience who are technicians, who are going to be working on farms, and so forth. Watersheds can be smaller than sub-watersheds. I have three on my hilly 260 acre farm.

In Rochester we are engaged at the moment in a project and have tried to sell it to the populace on these watersheds. I think it will catch on. I throw it out to the rest of you to make use of.

The Boy Scouts this year, as you may know, are doing a conservation good turn. We have sold to the local executive committee of the Boy Scouts to adopt a little watershed project for the Boy Scouts this year, and I think the Rochester community will turn out and handle a small watershed on 36 farms and all the little watersheds on the 36 farms. So, I draw to your attention that not all the watersheds are as big as the speakers would intimate they are. There may be several watersheds on the land on which you live.

VICE-CHAIRMAN COCHRAN: These comments bring it home to every one of us individually, that we may have a little watershed somewhere and certainly there is nothing finer than to get the boys and girls working on this, because watershed conservation is a long-time affair and to make continued progress on it can be done through their help and cooperation.

MR. FOX: I am gratified that Dr. Hargraves picked up this point of size. I was not trying to put a label of ten thousand or twenty thousand square miles. I was just trying to get everybody to thinking clearly of the tremendous area that we are taking into consideration sometimes.

Southeast of Des Moines, our local Chamber of Commerce adopted a little watershed of some 15 or 20 farms three or four years ago, and we have had one awful time now. We have discovered problems we never dreamed existed on that little area and I don't know how many more years we have got to go.

I don't want to say that in discouragement of the whole watershed idea, but I think we need a clearer understanding, and as the doctor said, don't bite off too much.

CHAIRMAN WILSON: Thank you. I am sure it must have occurred to some of us during the course of Dr. Hargrave's remarks, of the eternal truth of the old rhyme that says, "Little drops of water and little grains of sand, make a mighty nation and a pleasant land."

THE PLACE OF PARKS AND RECREATION IN OUR NEW PROGRAMS FOR WATERSHED CONSERVATION

HOWARD ZAHNISER

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As our civilization has taken over the wildlerness and has almost completely domesticated its own master, man himself, a great many of us have come to suspect pretty strongly that we can probably go much further in the long run if we don't go too far. We have not entirely recognized ourselves as domestic animals bound in the servitude of economics. In the midst of an atmosphere of conformity that we have heard called progress, there has been a measure of perversity. Some of us have claimed that it is more profitable not to manage some areas for profit. We have even argued that some of our areas of land and water should be so managed as to leave them unmanaged. Some of us have declared that the higher our culture the greater our appreciation of nature. One of us named Thoreau said that "in wildness is the preservation of the world." A phlianthropic society of peace-loving individuals has been organized to fight "for the freedom of the wildlerness." A member of it has been asked to talk here today about the place of parks and recreation in a very serious program to help farmers protect their investment in soil. And preverse as it may be, it all seems sound and in good order, for it is an aspect of the diversity through which we realize the unity of our common welfare.

On small areas devoted to private profit a particular enterprise can, of course, be carried on without an apparent concern for other enterprises. On units of land and water being managed in the public interest, however, the whole welfare of the public is involved. One of these interests is in safeguarding some areas in their natural condition, and still others in a condition so close to this as to provide for that peculiar activity of civilized man known as outdoor recreation. Thus, whatever the land-management unit is, planning in the public interest must include provision for outdoor recreation, for the maintenance of parks, and for the preservation of natural areas. For these all serve basic human needs, and in our civilization they are provided only deliberately, only through planning.

Our civilization is such that all of our land and water area seems destined for use by man. Furthermore, it all seems destined for commodity and other uses that require modification and development except for those areas that can be deliberately set aside, purposely protected in the public interest, and thus so used for preservation purposes.

This is indeed an important use. Civilized man has tended to remove himself from contacts with the rest of the natural world, and—except for those areas that through human wisdom and foresight are deliberately preserved—his mechanized civilization threatens to modify for human exploitation every last area on the earth. Were this tendency and these threats to continue, future generations gradually losing even the sense of the importance of the rest of the natural world to man, would be entirely deprived of access to natural areas. To those who now know the value of such areas and understand or surmise their human importance, such a development would threaten the end of our civilized culture and involve deprivations for future generations that would be fundamentally tragic. Thus it is that conservationists have sought to preserve an adequate system of wilderness and other natural areas and to develop an understanding and appreciation of their human values. If we succeed, we believe it will be possible for us to enjoy the conveniences and liberties of our urbanized, industrialized, mechanized civilization and yet not sacrifice an awareness of our human existence as spiritual creatures nurtured and sustained by and from the great community of life on the earth. It will be possible to have our agricultural areas for crop production and also our parks and recreational areas. For this use, this preservation use of lands, is part of the diversity within the unity of our planning.

It has become our policy, in the public interest, to preserve such areas through our instruments of government. The increasing awareness of the need for outdoor recreation and for the preservation of natural areas, has led to the development of what have been called zoning programs, and such programs have become an essential part of our land-management thinking. At the same time the importance and the character of outdoor recreation have led also to provision for it on any area where this is possible. A multiple-purpose ideal has been developed for realizing as far as possible the recreational opportunities on areas being managed for other primary purposes. Thus, through zoning and multiple-purpose administration, the land-management agencies within our political units have made impressive provision for outdoor recreation, for parks, and for the preservation of natural areas.

Through the Federal Government a national park system has been established that demonstrates most of the values with which we are here concerned. Its protection has become a public policy of the American people. It is true that this is still challenged at times by those who would exploit areas in the national park system for contrary purposes. The present Secretary of the Interior is, in fact, even now advocating a program developed by the Bureau of Reclamation to use the scenic wild canyons of Dinosaur National Monument for reservoirs to store water and produce hydro-electric power, and this threat from the high official of our goverment who is charged with the protection of the national park system is indeed a challenge to all those who uphold the public policy for national park preservation. The challenge, however, is being met firmly and spiritedly. Protests in amazing numbers have reached the President of the United States, the Secretary of the Interior himself, the Representatives and Senators in Congress, and the letters-to-the-editor columns of the press. A petition of protest against these dams proposed in the Dinosaur National Monument is being signed in the entrance to this convention room, and I trust that all here who have not yet done so will endorse it with their signatures. In all parts of the United States the protection of the Dinosaur National Monument is a deep concern of conservationists, not only for itself but as a means of establishing even more firmly our policy of national park system preservation. With such support continuing, as it most certainly will continue so long as the threat persists, it is our tense expectation that this policy will be respected by the Congress and the offensive dams rejected in favor of the alternatives which have been so effectively indicated by General U. S. Grant and others.

Through the Federal Government the national forests also have been so administered as to demonstrate these values we are considering. Wilderness, wild, primitive, roadless, and natural areas have been set aside for special protection, and all the forest areas have been managed to serve the multiple purposes that include picknicking, camping, hiking, fishing, and hunting. Other federal lands have also been administered to serve these multiple purposes, including the preservation of special areas.

Our states similiarly have established parks and forests and various provisions for outdoor recreation. Our towns and cities and some of our counties have demonstrated further that the provision for these human needs is an essential concern in the goverment of any unit of our people or of the land that they occupy.

Government at all levels has thus recognized the importance of parks and recreation to our individual and common welfare.

Now we are concerned with a new land-management program, one planned on a new basis, for and within a new kind of unit. Now we are concerned not primarily with a political unit of the land but with a natural unit. We are relating our interest to particular systems of streams, of springs, ponds, and lakes—relating them to watersheds.

We are excited at the neatness of this new and natural way of defining our unit of operation, and we may well be. Who knows but that we may thus have discovered a true natural unity for a variety of conservation interests? Most certainly, we are eager to see every possible concern brought into this watershed program—not only for the better handling of each concern but also for the perfection of the watershed program itself, for its perfection and thus its better chance for public acceptance and continuation.

We do well then, it seems to me, to consider how the watershed conservation program can benefit from and provide for outdoor recreation, maintenance of parks, and the preservation of natural areas. The particular practical program that happens at present to be underway may be desribed more precisely as for aid and assistance to farmers and others benefiting from flood control and soil conservation than as a program for the broad public interest or the general welfare. Its potentialities, however, are great and broad, and we shall do well to develop our concept as fully as possible. Perhaps in this very development we can demonstrate the cooperation that can make the broad program a reality and a success.

In establishing then the pioneer patterns for land management within the natural unit of the watershed, we should most assuredly take advantage of our experience with land management in the traditional political units. As in these historical programs we have seen developed gradually over the years, in response to popular demands or with the vision of leadership, the policies now so firmly held, it would certainly seem wise to be prompt in a new program in recognizing the importance, thus already demonstrated, of providing for the maintenance of parks and natural areas and for the recreational multiple use of any land or water areas that afford the opportunity.

Stream stabilization that also insures clean waters can have marvellously beneficial results in providing recreation. Ponds and reservoirs, whatever their prime purpose, appeal to people as places of rest and recreation. The woods and fields are part of the healthful habitat of man and should always be thought of as such. What excellent opportunities thus seem afforded by streams. lakes, reservoirs, ponds, woods, and fields for the multiple-use planning that can so well help to meet the needs for recreation in the watershed!

Some of these opportunities may possibly be best realized in some watersheds through the establishment of parks. Wherever parks are in existence, it would seem that their administrators should be among the cooperators in the watershed program, and where there are none or not as many as are needed, or possible, the planning of the watershed program might well include a stimulating of park projects.

The watershed program, like the soil conservation district program, may perhaps afford an especially favorable opportunity for the preservation of smaller natural areas—areas of special "local" value that are too small to be adminstered effectively by state or federal agencies. Occasionaly the donation of such a tract is offered to a state or federal agency or to some national organization, only to be refused because of the lack of a means for exercising responsibility for care of the area. Such an area, however, might well be accepted and administered by a soil conservation district or a watershed conservation association. Such areas, like our wilderness and wild areas and portions of our parks, can serve basic recreational and educational needs and at the same time have scientific value as "norm sites." They can be living museums. In the aggregate these smaller areas of wildness are also of importance to our culture, along with the larger areas of wilderness, and they thus merit attention in our broad national planning of watershed programs.

A recognition of the place that parks and recreation can thus have in the watershed program can contribute to the program's success not only by bringing to it the rewards of good public relations and general public support. It may indeed have also much deeper benefits, for it can result in a clear understanding of the interrelations of watershed conservation problems. Natural areas are excellent water-conservation areas themselves, and they afford fundamentally important scenes for study and observation.

The clearer understanding that results may in turn be known not only by the people already now concerned with soil and water conservation problems but perhaps also by segments of the public that are in many cases as uninformed as they are powerful in our governmental processes.

With its provision for a local sponsoring organization, the watershed conservation program would seem to provide an excellent opportunity for having various citizen organizations represented for the purpose of planning for recreational and park presentation projects. Along with the soil conservation district officers and other farmer spokesmen, a broadly based watershed conservation association might well include representatives of sportsmen's organizations and other conservation groups now so recognized, but also representatives of women's clubs, garden clubs, Rotary and Kiwanis and similar service groups, the League of Women Voters, veterans' organizations, labor unions, church and other religious organizations, parent-teachers associations—whatever organizations or groups exist in the particular watershed and concern themselves with the public interest. These groups might in turn find themselves deeply interested, as indeed they should be, in the conservation program—and eventually in national conservation issues as well.

Many, many individuals, including a large number who experience the pleasure of the outdoors, have no knowledge or understanding of the benefits that accrue to themselves and their communities becuase of conservation programs. They may accordingly either totally ignore political, economic, social, and other issues affecting conservation, or even act contrary to what they would consider their own and the public interest if they knew the facts. At the same time, civic and social, church and labor, professional and business, women's and youths' groups—and many other special purpose groups and organizations—local, state and national—concern themselves with many problems which touch on, or are affected by, conservation. The watershed program might well be a most effective means for reaching such groups, for pointing out the relationships between their interests and conservation, and thus enlisting their counsel and support.

If we could properly determine what place parks and recreation and wildland preservation have in our general welfare and in our individual health and happiness we could know well their place in watershed conservation programs. On the other hand, if we can—through thought and experience—find out their place in a watershed program we shall most certainly understand better than ever their importance in all our culture. We are dealing with matters of fine importance. They are matters that are inevitably affected whenever we undertake to manage areas of land and water for commodity production or for the installation of conveniences for our human use. They are matters which are not easily placed in equations. Like the church sanctuaries, the museums, and art galleries, the parks and playgrounds in the midst of the industrial, business, and residential areas of our cities, these nature sanctuaries, parks, and recreation areas in the midst of our rural or forest enterprises are of incomparable value and can thus never be compared by any common measure. They are, however, of deep concern, and the concern is not alone for the pleasure and happiness that come to people with outdoor recreation but also for our basic human welfare—our individual and cultural health. They have to do with our relationships to the whole community of life and our understanding of this relationship and of all our relationships with God and man; in other words, with our spiritual welfare as well as our physical health and mental happiness.

We never quite know how to set their price but whenever we face the temptation to barter them all away for material gains we face also the question that Jesus asked: "For what shall it profit a man if he shall gain the whole world and lose his own soul, or what shall a man give in exchange for his soul?"

These are indeed matters of the soul, and they certainly have their place in our watershed conservation programs.

DISCUSSION

VICE-CHAIRMAN COCHRAN: Mr. Chairman, Ladies and Gentlemen: Mr. Zahniser has talked about something that makes a very strong and direct personal appeal to every one of us. I was thinking during the course of his splendid paper, what a dull, drab life this would be, without that peak.

Mr. Zahniser also reminded us, as Mr. Hargraves did a little while ago, there are some things we can do immediately, to accomplish some of these purposes at the same time we are making long-range plans for the big things of the future. It is a very wholesome point to be bringing up in connection with this discussion.

MR. HERBERT F. SMART (Utah Wildlife Federation, Salt Lake City, Utah): The problem of conservation and watershed management in connection with the national parks and monuments has several aspects. There are many of us in the West who sometimes think that perhaps because of the peculiar bents of individuals towards preserving one type of resource we overlook also the preservation of others, and that in winning the one, we may be losing the other. And the question of relative value enters into it.

We, in our State Wildlife Federation, have taken a position in favor of the construction of the Echo Park dam. We have done it after thorough consideration. We do not believe that the natural beauty will be destroyed. We think it will be enhanced and made available to many people.

We also take a position that the preservation of the water in our area is important. It is something that should be conserved. We also know that the Dinosaur Monument is perhaps the one monument that is different from any other in this, that at the time it was enlarged in 1938, express representations and promises were made to people out there that the enlargement of the Dinosaur National Monument would not prejudice the impoundment of waters in connection with the development of the Upper Colorado River project.

We feel there is another side to this story. We don't think it has been adequately presented to all of the people in order that they can make an intelligent choice. We feel there is a story that should be told; and we feel in this instance, we are working for the preservation of our natural resources and in this connection, the preservation water in an arid land. Thank you.

VICE-CHAIRMAN COCHRAN: Certainly at a meeting of this sort, we want to present an opportunity for presentation of all sides of these subjects. Some of them are controvesial and should be. Are there any other comments on the suject?

MR. WADE: When the Chairman announced Howard Zahniser's position on the program as an anchor position, he spoke with a great deal of truth. I consider this paper we have just heard, as one of the most signfiicant ones ever delivered in this conference, and I truly hope that some 620 copies of this particular paper can be made up in short order and sent, ten copies each to the 62 watersheds for distribution and study within those watersheds . I consider Mr. Zahniser's paper a great inspiration. It has lifted us above the material values which we oftimes consider of tremendous importance and in his statements he will send us home, I am sure, greatly inspired. We should all thank Howard for this very remarkable paper. (Applause)

MR. ZAHNISER: Another text might be, "All these things shall be added unto you.'' These things we have been thinking about are not in lieu of material values. They are often realized through the best appraisal of the material values.

The Dinosaur National Monument has been a comparatively easy perplexity for some of us conservationists who wish always to face these problems in candor and with consideration of all the values involved for we have felt that the Dinosaur Mounment could be preserved in its scenic splendor unimpaired without sacrificing any of the needed water supply for the people of that area. That has been the generous contribution of General U. S. Grant to our case, in his demonstration of the availability of alternative programs that could preserve this pristine area, and at the same time, provide for the needed water, hydro-electric power and other developments that are so well tied into the Upper Colorado River storage project, as you know.

Most of us, all of us, as far as I know, in these organizations, have the deepest regard for moral values, for the sanctity of agreements and commitments. When we learned of the existence of agreements with the people of that area, we took it very seriously. We investigated it. We found there were discussions in the 1930's with people of that area with regard to their prospective dam construction programs, as we put it, to the possible setting aside of the national monument. We found that those agreements were respected and they were effective in the provisions of the Presidential proclamation that established this area.

We have a fine democratic way in this country that has been followed from our earliest days. We argue, we discuss, we express contrary views in our body politic, and then we come to the determination of public policies. We establish a constant. We enact laws, we make Presidential proclamations.

The discussion of these is concerned with the National Monument and the prospective dam projects, and they were resolved when the President issued the proclamation in 1938, and in that proclamation specified that the dam project that was then under consideration would not be interfered with by the establishment of this monument.

That wording is very clear in that proclamation. It relates as to what is known specifically as the Browns Park Project. The Browns Park Dam would be 45 miles up stream from where the proposed Echo Park Dam would be and the site of the Echo Park Dam was not in the minds of the planners at the time the monument was established or at the time of the discussion with the people of the area.

None of us ventured to object to the construction of a dam at the Browns Park site, but we have found it necessary to oppose the use of that exception as the justification for the construction of a dam 45 miles down stream that would inundate the marvelous wild canyons of the Ladore and drown out the important recreational areas of the beautiful Yampa Canyon. It would make an island of Steamboat Rock, which rises 150 feet above the Washington Monument.

So, we have felt that in providing water for the people of the area and in respecting the agreements, we have kept faith and we have found it impossible to take any other position. We feel there is, on the other hand, a deep commitment to the future to preserve this area as part of the national park system.

VICE-CHAIRMAN COCHRAN: Thank you, Mr. Zahniser. Are there any other comments?

MR. MAYALL: I thought you might be interested, if you didn't know it, that in this particular matter, that unlike most of our problems, some of the Canadian provinces are perhaps paving the way a little. About a third of the population of Southern Ontario is now in areas that are under Watershed Authority control. That may not seem like a big population perhaps, but it is nearly two million people. There are fifteen authorities involved, ranging from the very small, 80 square miles, up to say 1600 square miles. But, I think you would call them small.

In all except one or two of those watersheds where surveys have been made, an extensive recreation survey of all land suitable for recreation has been made and tied in and integrated with the work of land use, forestry, soil and the like.

MR. SMART: Two comments. One is with respect to the proposition of General Grant's. That is an engineering matter and I am not an engineer. I am a lawyer.

I might add, however, that there are respectable engineers and competent engineers whom I personally know, who disagree with him.

With respect to the promises and representations made at the time of enlargement of this dam, I would like to say this. Two Secretaries of the Interior, one under a Democratic administration, one under a Republican, have held hearings on that matter and both of them have agreed that the representation went to the entire enlargement of the Dinosaur National Monument.

Thank you for your kind attention and letting me say what I wanted to.

VICE-CHAIRMAN GUTERMUTH: Mr. Chairman, Mr. Smart has inferred that two Secretaries of the Interior have approved the project under discussion. I would like to correct the record slightly in that respect. He obviously is referring to the present Secretary, who it has been stated by others, is getting quite an enviable reputation for the laxity with which he is considering some of the natural resources of this country. The other Secretary he referred to was Secretary Chapman. Secretary Chapman, I believe you will find, did not approve this project. He gave the Bureau of Reclamation in his department the "go sign" upon one occasion, but in the final action, he suggested that in view of his subsequent investigation of this particular project, that he thought that the alternates, those other sites, should be examined more carefully before any decision is made, and no real investigation has been made to date.

Now, so much for that, but I do want it understood, and if I am wrong about this, Mr. Smart, correct me please, only one Secretary of the Interior, Secretary McKay, has approved this project.

In talking about the project itself, I also would like to have it made clear for the record that there is no question about the need for the Upper Colorado River project. The conservation forces of this country have not opposed the Upper Colorado River Storage project. We realize the necessity for certain types of development in this area.

The big question is, shall it be the destruction of the Green and Yampa Canyons, which are of national park stature in the minds of a great many people, or shall we use those slightly less efficient sites, if you want to put it that way, which are adequate, but which are outside the boundaries of the national monument?

Now then, the merits and demerits of this issue have been debated at length in congressional hearings, and I want to repeat the one request that has been made over and over, and which should be given serious consideration. I do not know how many years now, three or four at least, we have been discussing this controversial issue; and yet, although we have spent a lot of time and energy and money in studies, plans, and hearings, there still has not been to my knowledge, an adequate appraisal of those so-called alternate sites.

Now, the main point of issue seems to be that one statement in Mr. Tudor's report to the Secretary—the only reason that Secretary McKay gave for his decision—was that there would be a greater water evaporation loss at the alternate sites than at the Echo Park site.

Now, that might sound like something serious and worthy of great consideration in an arid place such as the area under consideration. However, when you stop and think, and this was brought out by competent water engineers in the hearing—when you stop and think, and I am going to be very conservative, that more than 50 per cent of all the irrigation water of the West is lost, and is not contributing anything to crop production, I am wondering whether or not that bugaboo of a few thousand gallons or hundred thousand gallons of water, whatever it may be, in this particular project, should be the determining factor in this issue?

We, very obviously, are wasting by inefficient methods of irrigation in the West, billions of acre feet of water each year, and if that is the case, why make such a bugaboo out of the small water evaporation differential at this one location?

The thing we have asked, and I will conclude with this, is that a fair and comprehensive study be made of those two sities in question, and that this issue really be considered on its merits. (Applause)

MR. SMART: Mr. Gutermuth asked me to correct him if he were misquoting. I think you will recall two Secretaries of the Interior after hearings, found there was the agreement with these people in the West. I didn't say the Secretaries had approved the project.

VICE-CHAIRMAN COCHRAN: One more speaker and then we will have to go on to the next speaker to avoid transgressing on his time.

MR. FRED M. PACKARD (National Parks Association, Washington, D. C.): I don't want to prolong this discussion unnecessarily, but there is one question that has been raised by Mr. Smart, which I think should be answered as clearly as possible, because it is a very real one: What are these commitments that the Park Service is said to have made regarding Echo Park dam?

The commitments are stated in an affidavit that is signed by a former employee of the National Park Service, Mr. David Madsen. That affidavit relates to the hearings that Mr. Madsen conducted for the National Park Service in 1936 in two cities in Utah.

In order to become a commitment, I should point out, the commitment must not exceed the authority of the person making it; it must be reported to the person who has the authority to confirm at commitment and must be confirmed by that authority.

Mr. Madsen was a wildlife technician in the National Parks Service. In his affidavit he stated he was Superintendent of Dinosaur National Monument. There was none at Dinosaur at that time. It was under the supervision of Rocky Mountain National Park. Madsen was a supervisor of the C.C.C. Camp, working temporarily there. In 1936, Echo Park was unheard of. It was first planned in about 1941.

Mr. Madsen was instructed by the Director, in accordance with a letter from Secretary Ickes, June 8, 1936, that the subject of water development should not be discussed at that hearing. He read that letter into the record of the hearing. The one issue at the hearings in 1936 as the matter of grazing rights. There were commitments about grazing and the report to the Director by Mr. Madsen is concerned with one subject only, grazing. If Mr. Madsen said anything about water developments at that time, he was exceeding his authority, and he must perforce have reported on the Browns Park project. Echo Park was unheard of at that time.

The withdrawal of 1904 does not extend to Echo Park damsite by many, many miles.

Finally, the other point I would like to make is, this does not affect only one national monument. There are actually some eight national parks, where that would have an effect. Among them are Grand Canyon, Yellowstone, Kings Canyon, Mammoth Cave, and Glacier National Park. We feel that this dam imperils the integrity of the entire national park system. (Applause)

THE PLACE OF STREAM POLLUTION CONTROL IN WATERSHED MANAGEMENT

J. H. BENDER

Chairman, Pure Streams Committee, Pennsylvania Federation of Sportsmen's Clubs, Williamsport, Pennsylvania

It is a privilege and a real pleasure for me as chairman of the Clean Streams Committee of the Pennsylvania State Federation of Sportsmens' Clubs, to be invited to participate in this program. Our organization, composed of nearly 200,000 sportsmen, has spear-headed the drive for clean streams in Pennsylvania for many years, and while we do not take credit for all that has been done in that great Commonwealth towards the goal of clean streams, we have made a substantial contribution, and we have a very definite opinion as to the place stream pollution control should occupy in watershed management.

Since so many of the other aspects of watershed management, including irrigation, recreation, public parks and many of the industrial benefits, hinge directly on the availability of clean water, stream pollution control must take first place in most programs of watershed management. It would be impractical to think of the great watershed developments of this nation, such as the Tennessee Valley development, the Colorado development, the Columbia and all the others which might be mentioned, without prime emphasis on pollution control. However, each watershed presents a problem of varied usefulness and the degree of water purity must be largely determined by the main purposes to be served. In the Schuylkill River development in Pennsylvania, the clean-up of the so-called "dirtiest river on earth," the chief goal was to provide ample supplies of domestic and industrial water for the six million concentration of population in the Philadelphia district, while in many of our western developments such as the great drainage basins of California and the Southwest irrigation and power represent the principal benefits. In each case, clean water in sufficient volume to provide the service required, is of paramount importance, but the degree of purity needed will vary to some extent.

In all cases the public health is of first importance, and it cannot be maintained with a backyard of filthy polluted water in our rivers and streams. Enforceable laws on drinking water have brought under control in the United States such epidemics as typhoid and others, but lack of adequate pollution control on many of our great drainage basins is strongly suspected of being responsible for other infectious diseases, including polio, which are not completely under control. It is a fact, in portions of the world where very little pollution control is practiced, such as the Yellow river basin of China and the Ganges of India, the raging of uncontrolled epidemics, many of which are water-borne, take a terriffic toll of lives annually.

Much as has been done here in the United States in the way of pollution control—and it is very substantial looking back over the past twenty years—but actually we have only started on the job yet to be done. We not only have a large portion of the accumulated pollution of the past three hundred years to clean up, but we have problems of increasing perplexity coming up every day. With great developments in the chemical field, new and more powerful components and an ever-expanding industry, the problems of pollution control are growing by leaps and bounds. Now, with the release of atomic energy for industrial exploitation, the prospects of even more frightening problems for the sanitary engineer are in the making to meet the new problems of pollution control which this entirely new industry may bring. And, these problems must be met, together with those we failed to meet adequately back in the 1800's and the early years of this century, during the years of the first World War when we were too busy to take care of our obligations of pollution control. And, the things we failed to do in the depression years of the 'thirties when we were supposed to be too poor to control pollution, and during the hectic years of the second World War, when again we had to concentrate on the national defense and won, but at such a terriffic price in the way of added pollution in nearly all of our great drainage basins, bays and coastal waters all over North America. Gentlemen—the timetable of pollution control on many of our great watersheds is very rapidly running out. In fact many of our rivers have long since reached and passed the saturation point. They are no longer living assets for the benefit of our people, but deadly streams of virulent disease which threaten our very well-being as a prosperous and healthful nation.

The benefits of pollution control in watershed management are obvious. First of all, our national health depends so much upon it. It is just as important today to abolish our watershed cesspools, namely our badly polluted rivers, as it was 50 or 75 year ago to abolish the individual backyard cesspools in most of our cities at that time. Second in importance to maintaining public health, is to provide sufficient supply of clean water for domestic and industrial use. without which our nation cannot continue to grow and prosper. We are so rapidly running out of water that we cannot possibly go another 25 years without keeping what clean water we have left and reclaiming a large portion of that which has been lost through pollution.

Therefore, whether we like it or not, the time is here and whether we can afford it or not, we have no choice except to concentrate on the elimination of pollution.

Now: How to tackle a job of this magnitude?

1. By expanding the idea of watershed or basin control, to include a representative board or committee on every minor tributary, with a voice at the grass-roots in over-all planning.

2. By strengthening the agencies charged with the control of pollution. Unfortunately, we find today many agencies trying to function very badly undermanned and with a scale of wages paid that cannot possibly attract young and vigorous engineers needed for the job to be done.

3. By closely coordinating the efforts of all governmental agencies presently responsible for pollution control. This includes municipal, state and Federal Government. Let these agencies share the costs on an equitable basis.

4. By selling industry on the benefits and the profits, if you please, to be derived from pollution control. Many industries have already discovered through research that much of the refuse formerly sewered into our streams held valuable by-products of great marketable value. This applies in particular to many branches of the chemical industry, to synthetics, the oil industry, meat packing and just plain ordinary sewage which by conversion into fertilizer at present carries approximately 40 per cent of the operating costs of the sewage disposal plant for the city of Milwaukee. Let American ingenuity among our young engineers and scientists go to work more fully on this problem of profits from refuse and the results can be astounding.

5. To do this job, all of us must get wholeheartedly behind a nationwide drive for pollution control. It is a fact that when enough people want pollution control on a given watershed or stream, the program moves very rapidly in every direction. Therefore, it is still largely a job of education to create the public demand for pollution control.

Now, to elaborate briefly on these five suggested measures. By taking into positions of responsibility, persons at the local level, some of the grass-root support needed for pollution control can be engendered. No one is really interested in any type of project unless he is close enough to participate in it and to understand its purposes. Also, it has been demonstrated that more favorable acceptance of any movement is always obtained by local participition. An outstanding example of this is found in most school boards, which are sustained by local, state and federal funds, but function with a minimum of friction through the election or appointment of local members.

On the second point, strengthening pollution control agencies: It we recognize the magnitude of the task to be done, we will easily see the total inadequacy of the means most state legislatures provide in the way of funds. We must get across to our law-makers the dire necessity for pollution control. With water scarcities becoming more acute from year to year in various sections of our nation, it is high time responsible people take heed and provide the necessary funds for enforcement of pure streams laws and to enact adequate laws in states where they do not at present have them. In one state that I am familiar with, the average yearly salary for a sanitary engineer is from four to five thousand dollars, while the same engineer will easily receive from six thousand to seventy-five hundred in the same state from private industry. Under situations of this kind, the work of pollution control is bound to drag, and this and other similar conditions should be corrected immediately.

On the subject of coordinating the efforts of all governmental agencies, there is much that can and should be done to prevent the stepping on of official toes. Where watershed pollution control involves, as it very often does, whole areas of the country involving a number of states, certainly a cooperative arrangement must be worked out between the states involved and this is being done by many of the interstate commissions already in existence. In the interests of national health and welfare, certainly the Federal Government has a real stake in projects involving pollution control and should share accordingly in the responsibility and in the costs. Local government and municipalities should assume their rightful responsibility for purely local polluton control, with financial aid from state and federal government.

Under the heading of selling industry on the benefits of pollution control, there is another phase which is well worth considering from the stand-point of industry. This is the human relations benefits to be obtained in a community by promoting pollution control as a business policy. One tangible example of this was in my own experience. As president of the West Branch Manufacturer's Association in 1946 and 1947, part of our public relations effort consisted of a program of industrial waste control on the West Branch of the Susquehanna River in Pennsylvania. For many years, before the river had been polluted, it served as a great source of recreation for industrial employees. As part of our program we asked all our 125 members on the river and industry in the valley in general to quit polluting. Within a few years, the results were remarkable, with much of the industrial waste removed, boating and other recreational uses of the river again became very popular, and the good-will gained on the West Branch for industry has been well worth the cost of the program. This is only one small example of a very important angle of pollution control by industry. It is a fact that much of today's pollution is laid on the doorstep of industry, and there is a feeling in the minds of the public that industry should lead the way in helping to clean up what it has helped to create. The costs of waste treatment installations by industry are quite liberally deductible from income tax by yearly depreciation, and possibly this rate of depreciation should be increased to encourage industry in its pollution control measures.

Point five—the final recommendation for doing the job of pollution control: getting the public behind the effort. Nothing is more important than public support. We should support the effort in every way ourselves, by serving on sanitary disposal boards, on area or regional pollution control committees, by talking pollution control to our service club connections, to our chambers of commerce, our labor unions, our manufacturers' associations, our granges and other organizations with which we may be connected. In other words, we must be the Prophets of pollution control in our respective states. Get the support of our local newspapers and radio stations. But, above everything else encourage and promote the teaching of pollution control in our schools and colleges. Be sure to get across to the coming generation, the importance which clean streams and an ample supply of usable water will play in their future well-being. It is a fact, in our generation a stream was considered a means for the disposal of filth, whatever it might be. Some of us have long since learned the fallacy of this concept, but the vast majority of the adult public has not and quite probably never will. But, the coming generation must be taught the truth. Young engineers must be sold on the value of preserving clean water in the future development of our industrial plant. Just as modern design is injected into our creations of architecture, so the importance of preserving clean water must be written into the minds of young industrial America.

In fact, this is a must we cannot avoid any longer. Population and industrial growth make it imperative. We cannot continue to live in our own filth. Great sums have been expended to relieve slum conditions in our cities and this is certainly for the good. It is a fact that crime, disease and degeneracy breed and flourish in slum neighborhoods and reflect on the character of the people, particularly young persons who must of necessity live in this environment. The same condition is created by uncontrolled pollution of our watersheds and as an example of this condition, we have only to visit some sections of our Pennsylvania coal regions, possibly the most despoiled areas on the face of the earth. No one has ever driven through these sections without noticing the utter squalor of many of the people, the unemployment and desperate situation of their economic condition. Industry avoids these polluted and despoiled areas and the future of their people, of business and jobs, is very bleak indeed. Therefore pollution does affect people and areas adversely, just as slum conditions do in creating an economic situation which we cannot long continue to tolerate.

Now, the total cost of the vast job of pollution control on the watersheds and tidal waters of the United States is estimated at from 10 to 12 billions of dollars, and herein lies one of the greatest obstacles, which has slowed down the work everywhere—the heavy cost. However, it is high time we change our viewpoint on the cost of pollution control. Nearly everyone is agreed, we cannot continue at our present rate of polluting, without running out of water. Therefore, the cost, whatever the amount, is no longer an expense, but an investment in a facility vital to the economic future of America. This nation of ours has spent billions in various corners of the globe and in the interests of national security; these investments were wise expenditures. But, we must face the blunt fact that in order to sustain the productive ability necessary to maintain our position of national security, we must look to this investment right here at home. And, there is no expenditure we ever made which will more quickly pay itself out in increased national income, greater tax returns to government from now derelict lands along our rivers and a return of economic health to areas now blighted by extreme pollution.

In summing up these remarks:

The place of stream pollution control in watershed management—in most developments—is right at the top of the list:

1. A safeguard to public health.

2. An assurance of badly needed water for communities already suffering from shortages and a guarantee of continued ample supplies for those headed towards water shortages in the future if a program of pollution control is not started now.

How to do it . . .?

1. Follow the pattern of area or basin development with emphasis on every tributary and more grass-root voice in planning and control.

2. Strengthen and expand all pollution control agencies and coordinate their efforts.

3. Sell industry for its own immediate profit, future development and public good-will.

4. Intensify the effort of public education for pollution control, with special emphasis on the younger generation in our schools and colleges.

5. Do not be deceived into thinking the task can be further delayed; it can not.

The cost, while it is great, is an investment we must make, to maintain the health of America and sustain the efficient productive capacity of industry. Both safeguards are vital to our national security.

We cannot continue to progress without making this investment in up-to-date modern pollution control any more than we can continue to turn out modern products in our factories with antiquated, worn-out machines.

GENERAL SESSIONS

Wednesday Afternoon—March 10

Chairman: WILLIAM M. APPLE
Secretary, Arkansas Wildlife Federation, Little Rock, Arkansas

Vice-Chairman: CHARLES A. DAMBACH
Chief, Division of Wildlife, Department of Natural Resources, Columbus, Ohio

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WATERFOWL HORIZONS—UNLIMITED?

INTRODUCTORY REMARKS

WILLIAM M. APPLE

It is indeed an honor to have the privilege of presiding at this very important discussion. I feel that this group assembled here represents the best interests of some several million duck hunters who each year take to the marshes and other watering areas in pursuit of their favorite sport. Much of the responsibility for maintaining this popular outdoor recreation for future generations is dependent on the diligent planning and action which we will undertake at this meeting.

As in any other field of human endeavor, our leadership is less important to us than to those who come after us. It is for our youth that we are primarily planning. But whatever progress we are able to make will be well rewarded. It is my belief that the entire nation profits from the sport of duck hunting, which hardly has a parallel when it comes to the training of our youth in the principles of good sportsmanship and therefore good citizenship.

Our task is not an extremely difficult one. Fortunately, the present-day flight of ducks can be maintained with more certainty over a period of years than the numbers of most other game. The problem has simply resolved itself down to the proper maintenance of nesting areas and the protection of the flight on its journey southward by providing necessary wintering areas and refuges. The times have gone when ducks could wing their way southward over thousands of acres of wild, undisturbed forest and water areas and remain unmolested. Necessary agricultural practices have robbed the duck of his quiet sanctuaries.

We have witnessed the draining of potholes and marsh lands, the clearing of our forests and wetlands. The backwaters of our rivers, which normally furnish vast wintering areas for our waterfowl, are disappearing with flood-control practices. Every year we see the construction of more huge impoundments. And with the channelization of our rivers and the continued drainage of our wetlands, there seems to be a general attempt to rush the water from the natural wintering areas of the ducks into the streams, and on to the ocean. It is these factors which are creating our major problem for the future. And as the topography of the country changes, so too must we change our conservation practices.

We have now reached the period when the remaining territory available to the propagation and protection of the waterfowl must be properly cultivated and preserved. Otherwise, we will face the slow disappearance of our great flights.

I ask, therefore, gentlemen, that we review carefully, more so for future generations than for ourselves, the possibilities of maintaining in their natural form as much of our wintering grounds as possible. This may entail the purchase of such areas either by a state or federal agency. But this objective is paramount, regardless of how it is accomplished.

On today's panel is a group of men highly qualified to discuss this very important subject. And it is my belief that from this meeting we will embark on a sound program, remembering always that it is the youth of America who are looking to us for their future sport.

DUCKS NEED MORE THAN BREEDING GROUNDS

W. WINSTON MAIR

Chief, Canadian Wildlife Service, Department of Northern Affairs and National Resources, Ottawa, Canada

In dealing with migratory waterfowl which, during the course of their lives, require space and its attendant attributes in widely separated parts of the hemisphere, we are accustomed to speak of their requirements in terms of breeding grounds, flyway resting areas, and wintering grounds. For many years, indeed, we tended to view these needs as relatively unrelated entities and applied management of largely local character. Now, we have recognized the futility of manipulation within any one segment of the complex without relating our actions to the whole, and have coordinated our activities through the flyway concept. But, while we have come to know the inter-relationship of the physical requirements of waterfowl *per se,* we have fallen short of achieving the broader ecological understanding essential to integration of this resource into our economy, and to its ultimate survival.

A paper given before this Conference a year ago made reference to some of the problems connected with the breeding grounds of waterfowl. In saying then that our policy should be to manage our waterfowl in such a way that serious damage to crops is eliminated, while at the same time insuring that no game species is reduced to such an extent that reasonable opportunities for hunting cease to exist, there was an attempt to emphasize the need for recognition of the competition between man and waterfowl—ducks versus grain. We do recognize this competition on the breeding grounds and are attempting to gain insight into the problem through detailed study of the biology of the grain-eating ducks. We suspect that the solution lies in striking an acceptable balance between various types of land use.

The problem indicated between agriculture and waterfowl on their breeding grounds is but one of a vast complex of problems embracing our whole social structure. In agriculture alone we face competitive situations throughout the entire waterfowl range, through drainage, intensive and sometimes destructive livestock range utilization, agricultural methodology on the wintering grounds and intensification or agricultural effort to build up food surpluses, just to mention a few. In other fields we can add water utilization, power development, oil exploration and industrial pollution as major areas of conflict. It is apparent that this is no trifling problem, the solution of which rests solely with lip service to the local needs of waterfowl and to regulation of harvest; it cuts right across the warp and woof of our civilization. We are faced with a major problem in multiple land-use which must be resolved if we are to secure, for waterfowl, the living space essential for maintenance of wildfowling as a significant recreation.

The idea of multiple land-use is not new, but the application of principles involved leaves much to be desired. In all areas of human conflict involving resource use, it is difficult to maintain proper perspective since immediate gain tends to outweigh the long-term advantage; the obvious tends to obscure that which is ill-defined though no less real. It is not surprising, then, that waterfowl, which for the most part permit only of indirect expression of their worth through recreational expenditures and consequent human well-being, suffer in consideration of land use and values. I say it is not surprising, but we must not permit this apparent public estimation of worth to befog our vision of the real contribution that waterfowl can make to society—both now and in the future.

Waterfowl, exemplifying wildlife, today form an important component of our civilization. Their recreational and aesthetic values nourish us just as surely as music, poetry and prose literature—or TV. There is placed upon human life such importance that doctors and humanists strive to save it from ills and social retribution. In part, this stems from an appreciation that each human being is something more than animate clay; it stems from the knowledge that human minds encompass sensibilities that, though difficult to describe, are very real and permit inclusion in our vocabularies of such words as love, respect and human understanding—and sportsmanship. There can be no doubt that some communion with nature is essential to maintenance of this quality. Thus, while we cannot question the priority of progress and better living, we can ask ourselves to define, in our own minds, what elements contribute to progress and constitute the better life.

When we have made up our minds what we, as a population, expect out of life, we should be able to face the future for waterfowl with some degree of confidence. We should be able, through use of modern management techniques, to resolve our land-use conflicts without serious detriment to any interest. But we will need to face up to the fact of competition between waterfowl and man, and be prepared to compromise our interest accordingly. For ultimate solution of the conflict the compromise must be a real one; *i.e.,* it must embody modification of objectives and procedures by all interests. We may be certain that the concomitant requisite of full public understanding, wholehearted cooperation and participation essential to the task will not be easily achieved or readily maintained. A continuous and enlightened program of public education and information will be essential.

But, you may say, there has been an active public relations program for years. True enough; much has been written and said on the necessity for and mechanics of habitat control, and it is not proposed to recapitulate those points here. It is doubted, however, that public awareness of the need for a policy-taking cognizance of the desired balance is yet sufficiently extensive to provide adequate support for the major waterfowl management activities which must be an integral part of any effective multiple land-use program. Similarly, much publicity has been given to regulation of waterfowl harvest over the years. Our regulations may not have been of unquestionable virtue at all times, since harvests may not always have been adequate or equitably divided to give every citizen a "fair share." But they have been as good as public understanding would permit; they will improve satisfactorily only as public understanding matches the advance of knowledge.

Basic, then, to all the activities we foresee, and to all the ducks need, is better public information and understanding. The idea of good public relations is admittedly not a new one. But, as with multiple land-use, practice has not always met the needs of principle. Until recent years, government publicity on waterfowl was lamentably inadequate or totally lacking. Private releases, through newspapers and sporting magazines, were, during the same period, more voluble but hardly more informative, being directed largely to sensationalism or to destructive criticism of various governmental agencies charged with waterfowl management. Management techniques, regulations, activity or lack thereof, and waterfowl research and researchers were for long the whipping boys of self-appointed public opinion. Constructive criticism received small mention—if at all.

Happily, such days are largely a thing of the past, but there is still a widespread view that our activities are little more than subsidized bird watching. The material presented in scientific reports on waterfowl research and waterfowl management, if rephrased for consumption by the general public, and complemented by an earnest exposition of our objectives, would do much to dispel this attitude. Judging by much of the material of this type which is presently being produced by our better outdoor columnists and writers and by the improving public support we are receiving, some progress in this direction is now being made. But we have by no means proved our case. With all due apologies to such fine workers as Vogt, Leopold, Osborn and

Allen, there remains as a major task the exposition of the ethical background of our labors. Only the application of persistence and enthusiasm will enable us finally to secure the desired end.

I catch myself up at this point to realize that I am following an old familiar pattern. Reference to the writings and wildlife conference transactions of the past twenty, yes, thirty years, shows that these things have been repeated with almost monotonous regularity. Have we, somewhere along the road, missed our cue or perhaps had our vision dimmed? Have we lost sight of the forest through looking at the trees?

Without belittling the importance of continuing scrutiny and development of management techniques, one ventures to suggest that undue prominence has been given to the technical aspects of waterfowl (wildlife) conservation. Consideration of the fundamental values, and their forceful presentation through word and deed to the public generally, are more likely to result in properly integrated resource use. Certainly any eventual solution to the conflicts inherent in the industrial land-use-waterfowl complex earlier stated must rest with re-examination by the public of our way of life and a decision as to what extent we are prepared to compromise the various needs we feel. As waterfowl specialists, our working techniques are reasonably adequate; as citizens our broad objectives, and particularly the means by which we should pursue them, are ill-defined.

With news of atomic explosions and flying saucers with us almost daily, it is perhaps difficult to contemplate fruitful life in years ahead. But essential to a resource-conscious attitude and the complete integration of man with his living environment is an atmosphere of serenity and good faith. This may not exist in the world today, but it is within the power of the people to create it. If we take the view that there is nothing on earth that cannot contribute to man's satisfaction and development, and that it therefore behooves us to search diligently for the attitudes, policies and techniques to be applied to our resources to ensure that such full contribution is made, we may develop sufficient tolerance and humility to recreate for ourselves the harmony implicit in the annunciation of "peace on earth and good will towards men."

DISCUSSION

VICE-CHAIRMAN DAMBACH: Thank you, Mr. Mair. We have heard a fine presentation by a fellow administrator and biologist from the country to the north of us. He has given us some very challenging things to consider. Does anyone wish to direct any question to the speaker or to discuss the topic which he presented?

DR. HARRISON F. LEWIS (West Middle Sable, Nova Scotia): I have listened with a great deal of interest and pleasure to this excellent paper. I wish to make a comment which while small, is, I think, not minor. The paper refers to the need of increased public information and understanding. No one can question that I wish to say, however, that in my opinion, that does not go quite far enough. In thinking over the subject in recent years, I find it difficult to discover an additional word for the additional thinking and meaning. I haven't quite the right one yet perhaps, but I would suggest what is needed is, converted. And I am not using that in its religious connotation. We need not only increased understanding, but a different point of view.

WHAT THE STATES CAN DO FOR WATERFOWL

ROBERT A. WELLS

Secretary, New York Conservation Department, Albany, New York

If we could pile one on top of the other all the pages that have been written about the waterfowl problem and what should be done about it, we'd make the Washington monument look like a toadstool. The difficulty has not been in finding people to discuss the matter but in reducing all their ideas to a simple, practical plan of operation and in getting talk converted to action.

It looks as though we are at last approaching the point where our discussions will have more sataisfactory endings. People are coming to realize that waterfowl management is not a one-man show to be left entirely to George (in Washington) to handle, and George has indicated a willingness to share some of the responsibilities of waterfowl planning and action. As a result, we have had capable administrators and waterfowl workers of the State and the Federal Government getting together frequently to examine realistically basic questions and exchange ideas for their solution. Progress is inevitable when you have such cooperative effort.

The most important single development—one which many of us feel is the key to the widening of our waterfowl horizons—was the creation of the Flyway Council — National Waterfowl Council set-up with which all of you are famiilar. It provides the machinery we heretofore lacked for the production of practical plans of operation the stimulation of waterfowl effort and the coordination of all the activities which result. It is the means for converting talk into action—the only way we've found yet to make an adequate waterfowl effort. Therefore, unqualified support of and wholehearted participation in its Flyway Council are the first and foremost responsibility of each state in doing a better job for waterfowl. The Fish and Wildlife Service bears an equal responsibility to make this Council set-up work.

COOPERATION IS ESSENTIAL

This new approach is based upon the practical philosophy that the job of waterfowl management and the attainment of full development of the waterfowl potential are possible only by all agencies—Federal, State and neighboring countries—joining hands, each doing a full share of the tasks, and by getting private organizations to fit their activities into the program agreed upon. Because I have drawn the topic of what states can do for waterfowl, I also want to point out attainment of these goals is *not* possible if the states *do not* participate actively in the task of waterfowl research and management. As soon as the sportsmen of the various states recognize this, they will start to press for the extension of these activities.

To get the greatest return from this state effort as well as from the contributions of other cooperators, a clear-cut pattern of definite objectives is necessary in each Flyway, geared to meet individual Flyway needs and developed jointly by all hand so that full participation in the program will be assured. You can get that complete acceptance of such a pattern only by making everyone a party to its formulation. It follows then that states must not only wholeheartedly take part in this basic planning, but also unhesitatingly carry it out.

In connection with this and the subsequent investigation and management activities developed from it, both state and federal representatives in the Councils should be administrators who have sufficient authority to commit their agencies to the program and carry out the action decided upon. It is a waste of time to get together, have someone agree to a plan of action and then have him go home and be unable to carry out the commitment. This has to be a joint effort, and it is up to the respective state commissions and those responsible in the Federal Goverment to delegate the kind of representative authority which will make progressive, cooperative action possible.

THINKING MUST CHANGE

Full public recognition of the necessity for the treatment of the waterfowl problem on a Flyway pattern is vitally important, too. It is the only practical way to do the job. It therefore becomes an additional required task of the states—and other agencies as well—to get everyone to alway think in terms of what is needed in their own Flyway to solve its problems, rather than looking over their shoulders at what someone else has or does and worrying about what another Flyway gets in terms of regulations, etc. Only then will it be possible to get real Flyway management. This fundamental is clearly set forth in the statement of policy adopted by the National Waterfowl Council representing our four Flyways.

It must be quite obvious it's impossible in this or any other paper to spell out in detail all of the jobs which states can and should do for waterfowl under the varied conditions which are encountered in the four Flyways. That will have to come from the decisions reached jointly in each Flyway Council. However, I'm convinced state waterfowl effort should contribute to the following four objectives, and each Flyway program should encompass them:

1. Attainment of a thorough understanding of how waterfowl behave in all parts of the Flyway.
2. Development of a management program which will produce and maintain more waterfowl in the Flyway.
3. Enactment of annual hunting regulations which will realistically permit the greatest possible sustained annual harvests and which will be geared to meet individual Flyway needs.
4. Creation of a coordinated Flyway conservation education effort so that there will be thorough public understanding of and support for its waterfowl program.

MORE INFORMATION NEEDED

Achieving a thorough understanding of how waterfowl behave in a Flyway is necessary before we can really refine management to the point where it will be most productive. This, then, has to be the starting point for all our activities. We certainly can not claim now that we have any more than rough ideas of where waterfowl come from for each of the major waterfowl areas in our states, which routes they follow in their migration from summer to winter range, and who shoots what segments of these Flyway populations.

Although it is pretty generally accepted that breeding populations are associated with given nesting areas, we don't know for certain whether or not these basic regional breeding units also have continuous association with the same general migration stopping points and wintering areas, or what the variations are for different species. If there are such associations, we need to know them to make possible the application of management at the proper places to produce more ducks and to provide adequate harvests of the annual surpluses.

Questions frequently arise about definitions of sub-flyways within states, often involving parts of several states. There are also the even more troublesome questions about our present Flyway pattern and whether or not its boundaries are properly defined.

Answers to all of these questions can be produced only by banding. Banding also seems to hold much promise as a means of determining rates of mortality for various segments of the population. It is quite evident that instead of de-emphasizing banding operations, we should be stimulating them. A very substantial part of this task will have to be borne by the states.

State responsibilities under banding will take three forms. Because the start of our duck production line lies far to the north of us in Canada, determination of the answers we need must start there. Therefore, it will be necessary for the states through Flyway Council action to develop a method for underwriting a part of the cost of the representative sample production banding required in that region. This probably will involve a P-R project. The U. S. Fish and Wildlife Service, the Canadian Service and the provinces will share this job, I am sure, and it certainly would be very helpful if other agencies also participated in it.

Secondly, we will have to maintain in our states similar summer banding efforts to supply comparable data in relation to waterfowl production within our own boundaries.

Then, at least for the time being as a means of speeding up the collection of information on the relationship of various waterfowl areas until the broad breeding ground coverage starts to produce it, we should carry on a comprehensive pattern of fall and winter banding which will cover all the important waterfowl areas of our states. A volume of bands from a few stations in our states is not the way to get these answers. A comparatively small but statistically adequate number from a comprehensive pattern of stations sampling all our areas is what we need.

State field staffs also should have, through censusing, information on the distribution and peak periods of abundance in each of their major waterfowl regions. Obviously, they also will have to contribute to the collection of information for the measurement of production and kill.

States also must have an inventory of all wetlands important to waterfowl—existing or potential. This will determine for them where acquisition, restoration and development of waterfowl management areas can be carried out most effectively and where most productive opportunities to improve breeding grounds will be found.

There are, of course, other questions which occur to us. They do need attention but there is a practical limit to what we should try to do. Our most effective contribution on them may be to get capable personnel of the conservation departments and of our colleges and universities to give them their attention.

MAKING MORE DUCKS

The question of how to develop the most effective management program to produce and maintain more waterfowl in each Flyway can be better answered when the investigations already discussed have been completed. However, it is not necessary to wait until then, for there are a number of things which can be done now.

Production of more ducks and geese takes four ingredients—restoration of breeding populations on suitable vacant areas; creation of new nesting territory to accommodate expanding local populations; establishment of new breeding populations of additional species not now present; and maintenance of adequate resting and feeding areas in the migration and wintering range to support the increased populations.

The moment mention is made of increased production, the question of crop depredations rears its head. We should remember that this is a local problem. It is not a problem of all Flyways, and it is not a problem in all parts of any single Flyway. On this basis, we can have programs in every Flyway to increase production, even Flyways with depredation problems, providing we can find breeding areas not associated with focal points of depredation and work in them, or as long as we work with species which are not involved in that problem.

OPPORTUNITY IS UNLIMITED

Truly unlimited within our own state borders are the opportunities for development and management of suitable areas to increase waterfowl production. Here, we have much breeding territory which is vacant because we "burned out" local populations associated with them. Here, too, we have countless places to restore old or create new small marshes or potholes which breeding birds need.

Practices to speed this re-establishment certainly are called for, and we ought to be ingenious enough to develop them. The use of stocking in such a situation—purely for the establishment of a local breeding population—would seem to be justified, but it must be of demonstrated effectiveness before it is generally employed.

Delayed opening of the seasons until migration are in full swing and local birds are so diffused among them that they are less vulnerable to first gunning, apparently helps increase the resident populations. If they have adequate protection, the wandering fringe of these local populations should re-establish native species as breeders on these vacant areas.

We in New York have been experimenting with the stocking of propagated ducks for some time as a means of establishing new species as breeders. We do not yet have all the answers, and we are not now recommending the general adoption of duck rearing programs. I can say this: We still feel from all that we have learned that the approach we are making holds promise. We were able to get good production of high-quality mallards and establish local breeding populations with them. We have stopped stocking mallards now because they are widely distributed throughout the state. We are presently concerned with other species, primarily pintails and redheads. We seek to determine if we can increase the production of our small marshes by establishing new species which do not conflict territorially with our native nesters. It will be at least two years before we really know how good are our chances to succeed with them.

NEW BREEDING TERRITORY

When it comes to development of new nesting territory, we are not so vague. Small marshes or potholes in fertile soils are essental requirements for the greatest production of ducks. We are convinced in New York that the building of these small, shallow water areas is the most beneficial improvement practice we have found to date. It not only produces ducks and furbearers, but, in our experience, helps other small game as well.

During the past year, we built 179 small marshes. These involve more elaborate impoundments with water-control structures and average about six acres in size. We also built 446 potholes. These are water areas less than an acre in size with simple earthen dikes and sodded emergency spillways. Utilization of these small marshes by breeding waterfowl has been very satisfactory.

I have placed great stress on this waterfowl activity because we are convinced it is one which should be employed by every state to bring about increased production. Remember, too, that small water areas like these help other game. The initiation of a smiliar effort by Ducks Unlimited and other private agencies to stimulatee such a program in agricultural regions of Canada also is worth very serious consideration.

The need for the acquisition of major wetland areas important to waterfowl, either to insure their preservation or to provide for their restoration or improvement, also will have to be met by states in many instances. As more information is collected by the cooperative investigations developed by the Flyway Councils, priorities for certain acquisitions to meet Flyway needs in relation to either migration or wintering ground deficiencies should be given emphasis.

REGULATIONS AND EDUCATION

The principle of making everyone a party to planning a program to assure full support for and active participation in carrying it out applies as much to hunting regulations as it does to the investigations and development phases of waterfowl management. The Flyway Councils and the National Waterfowl Councils supply the machinery for the Fish and Wildlife Service to use this approach.

Regulations which we had in the past did not adequately meet our needs. Improvement was made when treatment by Flyways was initiated. Now, there must be further refinement to deal with the smaller sub-flyway segments of the population, regional conditions and special species problems. The additional information we produce under expanding investigations will guide these changes which will be welcomed by the sportsmen.

It will be a responsibility of the states to seek only those modifications which are reasonable, and to support them with data showing them biologically sound and in the interest of good waterfowl management. It is also important that the states and the Service realistically adopt regulations which everyone will enforce. And people must understand that treatment cannot be the same Flyway by Flyway.

Getting public understanding is perhaps as important as any job we have in connection with the waterfowl problem. If we are going to attain better observance of regulations, people have to know about and believe in their necessity. If we are going to get public support for the waterfowl programs we have in our Flyways, people have to understand them. Why, it is even questionable now that many know there is even such a thing as a Flyway Council, let alone having any idea what it seeks to do.

The states do have educational and publicity facilities to deal with this problem. Apparently, there is needed from the Fish and Wildlife Service for each Flyway, to tie this job together, a public relations coordinator to function in this field in the same way that the Flyway Manager operates with the Flyway Council as a coordinator of investigations and management. This is something for the Councils and the Service to consider.

It also must be clearly evident that all agencies concerned with waterfowl—the states included—must take from here on out a positive, unhesitating approach to every phase of the waterfowl problem which is tackled. We will never win public support with uncertain talk or action.

DISCUSSION

VICE-CHAIRMAN DAMBACH: We certainly heard something vastly different from what was heretofore discussed at this conference. Usually the approach has been that we ought not to do this and we had ought to do that. Here, a man representing a state agency presents the hand of cooperation to the federal agencies and challenges his fellow states to work together with those agencies in solving our waterfowl problems. Certainly that is a very challenging proposal that is worthy of considerable discussion.

Does anyone care to comment on this paper? In the absence of immediate response, I would like to pose a question and paraphrase the title of the talk a little differently than it is in the program, "What the States Can Do for Waterfowl." I would like to direct a question to those representatives of the different Flyway Councils in this manner: What are the flyway councils doing? I think there are many in this room who obviously are not aware of the role the councils are playing and what plans are afoot as far as joint participation of the waterfowl management is concerned.

Mr. Wells, would you comment as far as the Atlantic Flyway is concerned?

MR. WELLS: Well, the one very encouraging development that we have in the Atlantic Flyway is that we are making a very realistic approach to attempt to procure the fundamental information on behavior that we do not have today. The representatives of the Fish and Wildlife Service, the Canadian Wildlife Service, the Ducks Unlimited, and we are attempting to volunteer additional help from our states to make possible the collection of more information that we need from Canada. We have carried on a number of very interesting cooperative activities to collect information about management techniques, and to stimulate the application of techniques.

We recognize very greatly the lack that we have at this time, to have a coordinated educational and public information effort, and because we have struggled with this ineffectively in the past is one of the reasons for the suggestion which was incorporated in the paper.

These are some of the things we work very closely on with the other flways to attempt to support them in their similar approaches.

VICE-CHAIRMAN DAMBACH: Chester Wilson, I am not sure you were in on the Flyway discussion the other day when the states in the Mississippi Flyway committed themselves to some cooperative effort.

MR. CHESTER WILSON (St. Paul, Minnesota): I am sorry to say I wasn't at that meeting. Maybe Frank Blair is here and he may be able to touch on that.

MR. BLAIR: I made the statement the other day, if we can amend our research project, we would be glad to supply one man to join them in a survey.

VICE-CHAIRMAN DAMBACH: As I recall, most of the states in the flyway indicated they would cooperate and send personnel.

MR. BLAIR: If I remember correctly, I think there were four of them for sure who were glad to cooperate.

VICE-CHAIRMAN DAMBACH: Does anyone from the Central Flyway wish to make a comment on this?

MR. THOMAS L. KIMBALL (Colorado Game and Fish Department, Denver, Colorado): I think that great strides have been made in the Flyways cooperating with not only the Fish and Wildlife Service, but with Canadian officials in the collection of data. Heretofore, it seems that state, federal and Canadian agencies as well as even independent interested sportsmen's group have been operating independently. Many times their efforts were not coordinated, the data was conflicting, and I think in many instances confusion reigned supreme. I definitely think that progress has been made in the cooperating effort. Now, I think even our technical groups meeting together to determine techniques of midwinter surveys, techniques in nesting ground studies, which when coordinated will be used by the Fish and Wildlife Service in developing their hunting regulations, which I think is a major step forward and most of the states, Colorado included, are willing to lend whatever effort they can in the way of personnel and equipment to assist in that.

WATERFOWL POTENTIALS

JOHN L. FARLEY
Director, U. S. Fish and Wildlife Service, Washington, D. C.

The topic suggested to me for this panel discussion is Waterfowl Potentials. It is a formidable title. It could include all of the things we strive for in research and investigations. It might embrace discussions and guesses of wildlife technicians, waterfowl gunners, and non-hunting nature lovers of the past and present. It might depict the visions of the dreamer. But this paper is not going to include these things.

The term "waterfowl potentials" means, I am sure, How many ducks and geese can we have in America, for how long? It points squarely to consideration of future habitat requirements and possibilities. It implies concern for the future of "public" duck hunting, recognizing that along with our rapidly increasing human population waterfowl habitat is fast dwindling.

Years ago, revered and respected Aldo Leopold wrote: ". . . the sportsman of the future must get his satisfaction by enlarging himself rather than by enlarging his bag." Nothing has happened since then to change the accuracy of that sage comment. As far as waterfowl hunting is concerned, we have two, three, possibly four times as many gunners as when Leopold made this remark.

Predictions have been made that by 1975 we shall have not less than 190 million people in the United States. If the predictions are accurate, and if the duck-stamp sale trend of the past few years continues, we will then have four million waterfowl hunters! If this should come true, then surely duck hunters of that not-so-distant future era will perforce derive their satisfaction from something other than the size of the daily bag.

Habitat, *breeding* habitat, *intermediate* flyway-habitat, and *wintering* habitat, will prove a limiting factor in future numbers of waterfowl. We can agree, I know, that regulations alone are not the key to waterfowl populations. Weather, on the other hand, *is* a major determinant in migratory bird populations. While weather is still beyond man's control, it cannot be excluded from any discussion of, or long-range plans for, waterfowl management.

We have learned that drought on the breeding grounds can cause tragic loss among waterfowl broods. When that happens, refuges and other managed areas along the flyways can provide life-saving food and water and resting places for the reduced "seed" stock of birds. We have seen that surprisingly small numbers of breeders returning north can produce almost unbelievable numbers of young, if breeding-ground conditions are favorable.

On both sides of the border, breeding habitat is being converted to other uses. The vastness of the effect of using power machinery to bring tens of millions of acres under the grain drill has shrunk natural production areas for ducks to a degree that is alarming to wildfowler and wildlife manager alike. We ponder ways to hold what we still have; we even hope, futilely perhaps, that we may find ways to *increase* what biologists call the "carrying capacity" of the areas within the four flyways. We do it in the face of ever-expanding conversion to agriculture, in the face of drainage, and both industrial and urban expansion.

The problem of meeting habitat requirements is becoming more and more critical. A quarter of a century ago it was estimated that about 7½ million acres of intensively managed habitat in public ownership would be sufficient to meet the over-all requirements in protecting a basic breeding stock of ducks and geese. This estimate was based upon a knowledge of comparatively large areas of wetlands under public and private ownership which appeared to be safe from drainage or other modification that would lessen their utility. A further consideration was the forecast at that time of the human population leveling off at about 150 million. The error of this planning now is evident. The reserve of wild lands is shrinking rapidly, and will continue to decline as the national population increases and agricultural economy expands. It is now evident that not less than 12 million acres of intensively managed habitat in all classes of ownership are needed to provide minimum requirements, if the waterfowl resource is to be maintained at somewhere near its present level. With the potential increase in hunting pressure in the next 25 years, even greater acreage under management will be required if we are to maintain the present level of hunting opportunities. Wetlands have been destroyed at a much faster pace than the conservation agencies have been able to acquire and restore lands to meet the most urgent needs. Over the past two decades, less than 5 million acres of waterfowl habitat have been acquired by the Fish and Wildlife Service and the state game departments. At the present rate, we are not even keeping abreast of current needs in problem areas and can hope to do little better without embarking upon an expanded acquisition program.

Research. Investigations. Management. These words have become everyday working terms to the many people from coast to coast who are concerned with the status of waterfowl. Here and there we see encouraging signs: Canada geese that use the Mississippi Flyway, for example. During two decades of "management"—cautious harvest, areas to provide safety, food, and water—the big birds' numbers have doubled. New local populations of geese have been established successfully; it appears that we can have honkers almost anywhere we want them. We can also lure ducks to "managed" areas, and hold them, while food holds out.

But concentrations bring problems: depredations, disease, and, sometimes, unsportsmanlike behavior of hunters around refuge areas, as well as protests from anti-hunters. It is possible, we find, to have more birds in limited bits of habitat than we can accommodate. Waterfowl potentials involve more than just wildlife management. Also are involved people—land owners, nature lovers, and gunners—who impose limitations the dimensions of which cannot be accurately estimated.

Waterfowl potentials involve the mangement of land and water areas acquired for that purpose, and we find differences in viewpoints in these matters. Last year I found myself in the midst of a very determined and sincere discussion involving the ethics and legality of using small portions of certain migratory waterfowl refuges for public shooting. The particular refuges in question were those purchased with funds derived from the sale of the one dollar duck stamp provided by the original legislation. These were designated as inviolate refuges. Under a subsequent act of Congress, the cost of the duck stamp was increased, and specific authority was given for the use of portions of areas acquired for waterfowl for public shoting. Under this authority, on one refuge, the Brigantine, public hunting was permitted in 1952, and, so far as I am aware, no exception was taken to its use in this manner.

In 1953, a management plan including public shooting was submitted to me for additional refuges purchased with the one dollar duck stamp funds. After approving some of them, I had visits, telephone calls, and telegrams from conservationists whom I hold in highest esteem, questioning the legality and the ethics of the use of lands so purchased for public shooting. I had already satisfied myself as to the legality of the plans, but not having been present during the discussions and hearings leading up to the passage of the two dollar stamp act, I was unfamiliar with some of the positive statements and positions taken at the hearings.

I have an old-fashioned sense of obligation about promises, and after a hasty reading of the records of the Congressional Committee hearings, I called our staff together to consider the situation and told the staff that if it were a fact that our Service or our Department had promised not to use these older refuges for public shooting, I would respect these promises and cancel the plans for such use.

In further study of the records and conversations with individuals participating in the changes made in the House bill which removed the inviolate feature of the older refuges, I had to assume that the House Committee members knew the effect of the change which was made and that the Senate in reconsidering its bill also knew the meaning of the change which was adopted. A careful reading of the Congressional Committee reports on the unchanged bill makes clear that the comments and interpretations made by the Committee, Department, and Service representatives refer to the bill before the change and clearly apply to its provisions only. There were no promises or interpretations made regarding the bill as changed, and the changes explicitly extended the authority to provide public hunting on the older refuges. Consequently, I felt that there would be no violation of promises and accept full responsibility for the experimental public shooting on several of the areas which were formerly considered inviolate. I have reviewed this situation at some length because there have been some misunderstandings and because I consider that the management of some of these waterfowl areas should, when conditions warrant, include some public shooting, and that such shooting as well as the habitat management are factors in waterfowl potentials.

There has long been agreement that to continue to have waterfowl hunting we have "to do something about it." If we let usable habitat become useless through lack of management, if we do not preserve some habitat by acquisition, neither ducks nor hunters will have places to sit down. Even thus simply stated, the problem—the task—remains complex and huge.

There was a time, not so long ago, when waterfowl management problems were rather generally considered to be strictly a federal responsibility. Now, states are as concerned and involved in them as the Fish and Wildlife Service and, in addition, several private organizations are lending dollars and effort and ideas to this truly national responsibility. We all accept now, I believe, the fact that to preserve migratory waterfowl in shootable numbers for even the *foreseeable* future will require investments and thinking of all conservation groups—state, federal, and private.

In this program, the states will have to assume major responsibility. Through their many Pittman-Robertson programs during the past 15 years, the states have acquired by purchase 410,452 acres of "waterfowl" habitat and, during the same time, brought under development and management 1,440,000 acres. The cost was almost 23 million dollars.

The rate of spending for the past five years' waterfowl projects under Pittman-Robertson (this includes acquisition, development, maintenance, and research) shows an all-states average of one-third of the annual Federal Aid outlay—16 million dollars in five years. Recent Federal expenditures in support of waterfowl—including enforcement, acquisition, development, and research — have been six and three-quarters million dollars per year. During the past 20 years, nearly 5 million acres have been acquired by the Fish and Wildlife Service and state game departments.

Yet, in the three states of North and South Dakota and Minnesota, pothole drainage has gone on at the rate of 32,000 acres per year—more than 315,000 acres in the past five years. These potholes are—or were—production areas; much of the 5 million acres referred to above is not production-type.

Despite big expenditures and sincere efforts, we seem to be losing ground! It is encouraging to realize, however, that there is now organized effort of state conservation agencies in the form of the Flyway Councils, whose representatives comprise the National Waterfowl Council. Through these organizations, the many states have accepted increased responsibilities regarding waterfowl. They will help solve the problem of shrinking waterfowl habitat.

More knowledge of the birds' needs; ingenuity enough to increase habitat carrying capacity; possible development of military lands (there are 3½ million acres suitable for wildlife management, of which some 10 per cent is estimated as suitable for waterfowl) are some hopes for the future. Information has very recently come in showing that one huge sectiton of the Northwest Territory, along the McKenzie River, has production potentials only *suspected* previously. The data show that this remote area is at least *equal to* southern Saskatchewan in breeding populations. Southern Saskatchewan is, as you are well aware, a part of what is often referred to as the "duck factory." At present it appears—if we are willing to be slightly optimistic—that our combined potential should be great enough to indicate favorable future waterfowl potentials.

We started this discussion with the statement that waterfowl potentials means How many ducks and geese can we have in America? Mr. Gutermuth's letter assigning me this topic included these words, "We would like to discuss the ultimate and maximum limits in waterfowl abundance that can possibly be maintained on this continent." I have discussed very briefly some of the things which may contribute to the potentials, but I do not find in myself, nor in our Service, the reservoir of facts or the gift of prophecy which would be necessary to make a forecast. I am intensely interested in the question. I would like to know definitely if we are waging a rear-guard action merely to delay the reduction of our waterfowl populations to some reduced level which can be maintained largely by public and privately owned waterfowl management areas, or do we really have the knowledge, the energy, and the financial resources to maintain or build up our present waterfowl populations? It has been said that the over-all state and federal costs of waterfowl management now approximate $1.00 per bird killed. Public and private waterfowl refuges and management areas provide for only a fraction of the present waterfowl populations, and even taking full credit for the undeveloped potentials of the management areas presently available, it would require several times these areas to care for the waterfowl if they were denied access to the privately and publicly owned land and water areas they are now using but which might be devoted to other uses, precluding use by waterfowl.

The cost of replacement lands and the necessary water will be much higher than our costs have been. The longer we wait, the greater the competition for these lands and water, and the greater the cost. The potential certainly has a dollar factor. What are we willing to pay per bird: two dollars, three dollars,—ten dollars as a production cost, plus the cost of hunting?

Continued studies, added experience in the management of waterfowl, the completion of wetland and river basin studies will make possible a realistic estimate of waterfowl potentials.

While I am unable to provide a numerical figure for these potentials, I believe the ultimate that can be attained is largely limited by our willingness and ability to pay the pyramiding costs which will accompany population increases and demands for recreation.

Reference has already been made in these meetings to the preservation of the integrity of refuges. An "Advance reprint of an editorial appearing in *Nature Magazine* for April, 1954, under the caption "In Whom Shall We Put Our Trust?" discusses this same situation.

The editorial referred to above contains these statements: "It was assumed that the Fish and Wildlife Service was administered by men of integrity, that the word of the Service could be relied upon. . . ." However, last year, the Director of the Service quietly . . . almost surreptitiously . . . opened five inviolate refuges: St. Marks, Wellapa, Lower Souris, Tamarac, and Horicon, to public shooting. Indeed, he authorized opening *all* of Horicon in Wisconsin, despite the limiting provisions of the law."

Please note that no mention in the editorial is made of Brigantine, a former inviolate refuge, which was opened to public shooting the year before. If it was a fact that a sin had been committed, the pattern was set then. Also, please note the error in stating that *all* of Horicon was opened. (Actually a much smaller area than the law permits was opened on an experimental basis.) And also, please note the statement: "The Director . . . quietly, almost surreptitiously, opened five refuges" .... Are advertised public hearings in the refuge areas called to discuss the plans for these public shooting projects really a quiet and surreptitious procedure? Such public hearings were held well in advance of the hunting sceason and certainly were accorded a great deal of publicity.

Finally, this editorial reads: "We hear a great deal nowadays about juvenile delinquency, and the fraying of the moral fiber of our people. If we cannot rely upon the integrity of individuals in public office, who should certainly provide leadership and example, in whom shall we put our trust?"

No one who knows me will in any way be influenced by that last paragraph. However, I am concerned about the impact of inaccuracies and false charges upon the many mature and juvenile nature lovers who rely on *Nature Magazine* for accurate information on conservation matters. Is the cause of conservation served by such methods?

Early in this session we were charged with a lack of dynamic programs. It is unfortunate that all too frequently people's judgment of the success or failure of the Fish and Wildlife Service is based upon opinions of the handling of migratory waterfowl problems. Frequently forgotten are its many other activities. For instance it has almost absolute control of Alaska's most important industry—its fisheries. Following a very poor pink salmon catch this year, drastic action was taken to completely close one large area to pink salmon fishing, and to reduce by one-half, the traps and other fishing opportunities in all of Southeastern Alaska for two years; yet I am charged with lack of dynamic action.

In what direction is the Fish and Wildlife Service going under my supervision? One outstanding man—a fisheries expert and a former director of Oregon's Department of Fisheries has been brought in as an Assistant Director to help make the management of our fishery resources a matter of real accomplishment and pride. Another man who has made a national reputation in the management of game and other natural resources in Wisconsin, has been secured as an Assistant Director. Why these men?

They are both skilled in, and respected for their knowledge of state fish and wildlife problems of research and management. They will help carry out one of my major objectives in building up the respect of the states for the federal service, securing their complete cooperation, and in having the states assume their full responsibilities in the management of the wildlife resources in which the federal government also has responsibilities.

Some years ago, when state fish and game departments were less stable, underfinanced and lacking in know-how, there was good reason for the Federal Government to assume a dominant and at times dictatorial position. But, states have grown up. They have the skills, the ability and the means to develop and carry out long range projects.

The tendency will be towards greater state participation, and greater responsibility in areas of common interest.

DISCUSSION

CHAIRMAN APPLE: Thank you, Mr. Farley. I believe that after the presentation of that very fine paper, the audience will agree with me that our affairs are in very capable hands.

VICE-CHAIRMAN DAMBACH: Thank you, Mr. Apple. Those among us in this audience who have responsibilities for administering wildlife resources on that state level, can greatly appreciate the enormous task facing Mr. Farley and can heartily sympathize with him in the report of the way some of his sincere efforts have been interpreted by the public and some of the agencies and reformers who ostensibly are reporting the facts to the public.

As I see it, his paper divided into two parts, one having to do with the waterfowl potential and the other was laying bare the basic policies of his organization in dealing with these problems and others. And he has done a fine job of presenting to us the problems in the matters that should be discussed by this group and we are now ready for such a discussion. Does anyone care to direct any questions to Mr. Farley or to discuss the paper otherwise?

MR. WALTER HAUPT (Milwaukee, Wisconsin): I would like to talk about the Horicon Marsh. The water level has been raised and the Fish and Wildlife has set a perimeter around the outside of the marsh for public hunting. It has established approximately 90 pits, and these pits are within the feed grounds. As far as shooting went this year, there were less than a thousand geese taken at Horicon and everyone I talked to was well satisfied with the experiment and will be glad if it is continued the way it has been in the past year.

MR. H. R. MORGAN (North Dakota Game and Fish Commission, Bismarck, North Dakota): The Director made mention of the fact that certain drainage was going on, particularly in the States of Minnesota, North and South Dakota. I will grant that very definitely is a fact.

The thing that occurred to me and I would like to direct this question to the Director is, do you not agree, that both on the state and central level, we may have been a bit lax in determining the value of some of our potholes or productive areas? I will grant you that the Service has very definitely determined the value of the refuges and inviolate refuges and production areas, but I wonder if we in the states and services as a whole, have not been a little lax in trying to determine the production value of some of those areas which do not lie within them; and in being lax, have we not lowered the value of some of the arguments that we might otherwise have against drainage?

MR. FARLEY: I am sure that you are correct in that. In fact, you know that so well, it was quite unnecessary to ask the question, but I assume you wanted a little more emphasis on it than perhaps might otherwise occur.

Yes, these recreational values are intangible things and I know from my own experience that we do not recognize the values until they are either threatened or are gone. However, in making up these reports, we have been bound by very rigid ground rules, and I am sure that the state-made assessment under the ground rules we have to apply, is inadequately expressed in dollars and cents as to the value of those resources. I heartily agree with Mr. Morgan.

MR. CHESTER WILSON (Minnesota): Mr. Chairman, following up that point that Bud Morgan put his finger on, I think it is perfectly obvious in order to meet the goal that Director Farley mentioned of getting the total of 12 million acres of waterfowl area under intensive management, we are going to have to acquire a lot more areas outside of the established refuges, and as a basis for acquisition, we have to locate the spots and evaluate them. And as the Director knows, we up in the upper valley states, are initiating programs to that end and only recently have we received from the U. S. Fish and Wildlife Service and from our own field forces, enough definite information to have an idea as to how far we must go. I would like to ask Mr. Farley if he could break down that 12 million acres a little bit and tell us how much of that remains yet to be acquired, and roughly speaking, where the areas are or how much the acreage is that the U. S. Fish and Wildlife Service estimates needs to be acquired in the different important waterfowl sections of the country.

In other words, what we want to get at, we want to know how big is Minnesota's job, and Bud Morgan wants to know how big is North Dakota's job, and so it goes. I think it would be helpful to all of us if Director Farley could give a breakdown on that.

VICE-CHAIRMAN DAMBACH: Are you in a position to answer that?

MR. FARLEY: Well, I would appreciate your doubt that I am. I brought it out for two reasons. In my own thinking, I wanted to see where we are going and what we have left to do. I am not prepared at this time to answer specifically, but we are trying to dig into that and get information out so we can assess the many responsibilities which we have.

And may I add in that connection, I had so many things that I wanted to tell you, so many problems, that I just had to leave out a vast number of them. Each one of them seems to be just about as important as the other. When you are talking about purchasing land, we have an increasing problem of how are we going to accomplish it. Under the requirements of reduced spending of the General Fund, more and more of your Duck Stamp money is being used for the development and maintenance of refuges and at the present rate, that change is of but a short time and all of that revenue will be in maintenance and development and law enforcement and the other activities that are properly charged to that source of revenue. So, I throw it out here as something that must be seriously thought about until we call a halt to this refuge program in the way of expansion.

MR. THOMAS L. KIMBALL (Colorado Game and Fish Department, Denver, Colorado): Mr. Farley, I wish you would elaborate a little on the Duck Stamp money. A number of us view with alarm the amount of money which is being diverted to research activities, to development and maintenance, which some of us think is directly against the intent of the law. We think that more of that money should be spent on the acquisition of lands and it disturbs us no end to see the policy being changed to spending more and more of the money on the positions that you have mentioned.

I wonder if that is going to continue to be the policy that more and more of this money will be used for such purposes and less and less for the actual acquisition, which I believe is stated in the law.

MR. FARLEY: Answering the question in two parts, I believe that the authority for its use as contemplated is there. Were it not there, I certainly would not dare subscribe my name to any plans that contemplated that.

Lest there be a misunderstanding, the urge to use that money for other than purchase of refuges in a large way, does not stem from Fish and Wildlife Service. I think I have commented rather thoroughly on the tendency, and that is about all we can say. It is there and unless there is derived some means to change that course, that seems to be the course that is being steered.

MR. RALPH G. COOKSEY (National Wildlife Federation, St. Petersburg, Florida): I would like to direct this question to Director Farley. I noticed that the gentleman from Canada and one from New York and Director Farley have covered many phases of this subject. However, there is one that seems has been neglected, and that is the wintering areas for at least the seaboard or the Eastern flyway.

The Canadian situation is well under control, it seems, but as far as the

Cuban and the islands down by Florida are concerned, I wonder what the thinking of the Department is along that line, because there is no regard for the ducks that go South on the territorial waters in the way of contributions or Duck Stamps or anything else. And that is a very hot potato I know, but we in the southern part of the country would like to know what is cooking along that line.

MR. FARLEY: There have been a lot of discussions. Certainly, we realize the importance of what you speak of, but there are, I am sorry to say, no specific plans which I am sure of at this time.

MR. SETH GORDON (California): I am not going to ask the Director a question, but I think this group should know certain facts. I want to direct my remarks to a statement made about the original intent of the Duck Stamp money. Anybody can go back and read the record and know definitely what that money was contributed for.

I realize it is not the fault of the Director of the Fish and Wildlife Service. It is primarily the fault of the Director of the Budget, who is operating under the direction of the administration. And it doesn't seem to matter whether the Democrats or the Republicans are in office, when there is a special fund upon which they can draw, they will spend the special fund monies and save general tax funds.

We ought to be buying more of these marsh areas right now, instead of delaying until they are unavailable. I do think that the Duck Stamp money has not been too wisely administered. I think definitely we have not used enough of that money to fortify ourselves against future needs.

Mention was made earlier about the flyways; the Pacific Flyway did not respond. I just want to say, in my opinion, the Pacific Flyway is as well organized as any of the flyways, and I am glad to say the states are working with the Fish and Wildlife Service to do a dual job, not putting it all on the federal government.

In the State of California, we are working with the Fish and Wildlife Service to develop a series of multiple-purpose waterfowl management projects, a portion of them for refuge, a portion on which to raise feed at considerable outlays of money to prevent depredations on farm crops, and a portion of them for Public hunting. And in California alone, we have set aside a little over four million dollars out of twelve million dollars of horse-racing money on that project.

Our big problem is in the wintering regions of the several flyways, and we need to do something on the Mexican side of the line, as those of you familiar with conditions are well aware. We ought to find a way to help our neighbors to the South. And for the benefit of the next speaker, in view of the grand job they have done on the breeding grounds, I think it is time they use some of their money on the wintering grounds to provide a place for the ducks and geese to live.

Mr. Farley made reference to a magazine article which criticized what the Service did in opening a portion of some of the waterfowl refuges to hunting. In no case did anybody suggest that entire areas be opened up. Nobody ever so recommended, and in no case has any large portion been opened. When we speak of opening up these refuges, we should make clear *only a small portion* of them are being opened for public use.

The gentlemen from Wisconsin told us what has happened around the Horicon, and that is one of the basic reasons why we say that in many instances portions of the refuges should be opened to public hunting.

Last fall, we had a situation arise in our state where we felt that the U. S. Fish and Wildlife Service should open a portion of the Sacramento Federal Wildlife Refuge. It was bought with funds secured by special appropriation, not out of Duck Stamp money. And what happened?

I yield to nobody in this ground when it comes to maintaining that bird protection groups have a right to insist that our birds should be protected so that they can enjoy looking at them.

When it looked as though the Fish and Wildlife Service might comply with requests from the Department of Fish and Game, including those of the farmers who were getting considerable damage, people who owned private gun club property and had shooting blinds on the very borders of the refuge, began pulling a fast one. They went to the Audubon Society, to the Nature Association, and every other group they could think of, all of whom they had been fighting for years, and told them what a terrible thing was about to take place; that one of the species of geese would be destroyed forever, and all that sort of bunk. And the good folks fell for it.

There was no intention to open any sizable portion of the Sacramento Refuge, but the good folks jumped in head over heels and stirred up determined opposition to opening any part thereof. The private clubs who owned the ground adjacent to the refuge pulled a fast maneuver and caught everybody napping. So hereafter let's get the facts and avoid being taken for suckers.

VICE-CHAIRMAN DAMBACH: Thank you, Mr. Gordon.

MR. RICHARD W. WESTWOOD (American Nature Association, Washington, D. C.): We have been quoted out of context by Mr. Farley, and I would suggest that the people read the editorial in its entirety. I would like to ask Mr. Farley if his investigation, on which he based the satisfaction of his own conscience in this matter, disclosed the fact that those agreements were taken out of the bill without the knowledge of anybody, including the man responsible for the amendment, Mr. Shoemaker; and also I would like to know why Mr. Farley did not quote this paragraph from the House Committee report and the Senate Committee report.

''There is nothing in this bill that will authorize the opening of areas heretofore characterized as sanctuaries and it is not the intent of your committee that the presently existing santuaries be opened to hunting.''

MR. FARLEY: Yes, I am very glad to answer that. I spent a good deal of time trying to get the background of those things that took place when I was back in Washington. I have the word of one member of Congress, a member of that Committee, who was present during all the action. I have the statement of another person who had an official connection with the Committee and was present during the discussions, and I have had the very positive assurance of both of those gentlemen that the committee members who made the change in that date, fully understood exactly what they were doing and that there was no effort to handle it in a way to deceive anybody.

Now, why the rest of you who were watching that were not informed, I do not know, I am sure.

Regarding the statements that you refer to, those certainly were the things—I am speaking of the statements made in the hearing of the directors—those were certain things that at first challenged me very seriously. I think if you will read those very carefully with the other material that goes with them, that you will find they specifically refer to the bill before the dates were removed and they carry this language—. ''This bill does not do certain things.''

Now, as to the statement of the Committee itself, that seems to be an overall statement, but again it was made and applied to the unamended bill that was under discussion, and I think my obligation runs largely on the feeling of what our Service had promised and what our Department had promised and not to the same extent that the Committee members might have, because these same Committee members were the people that made possible the changes referred to, and I am not sure but what there must have been a change in thinking.

MAN IS THE LIMITING FACTOR

ROBERT M. GAYLORD
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The question mark after "Waterfowl Horizons—Unlimited?" raises a skeptical eye at the title, and properly so, for waterfowl horizons are limited—they always have been limited and always will be—limited by many things and in many ways.

If today only a few tribes of aborigines wandered over this continent, flocks of waterfowl would again darken the skies, but the extent and the density of that darkness would vary from year to year as Mother Nature put her limit on the flocks. There is an old folk saying amongst the Swedes that "God does not let the trees grow to the skies." Neither would he let ducks blot out the horizons. When I scan the topic assigned me, "Man is the Limiting Factor," I hasten to point out that while man is *a* limiting factor, he is not *the* limiting factor, and to add that which is much more important, he may be a stimulating factor.

Historically, man is a limiting factor bcause he:

1. Evicted the waterfowl from their ancestral homes—by literally throwing them out of the places they have occupied since "the memory of man runneth not to the contrary." He trampled, plowed and drained the nesting grounds, destroyed the feeding grounds and made untenable the resting grounds.
2. He has killed by shooting or trapping both for sport and for food.

And he is continuing these same activities today.

At the outset, the hunter and trapper were blamed almost exclusively. Game hanging in the market place and bags brought in from the camps gave visible evidence which seemed to explain the increasingly smaller flocks of ducks and geese.

Then came the farmer, rancher, and engineer—all equipped with civilization's most effective tools, until now after perhaps three-quarters of a century of vastly changing conditions, we know that hunting is only one of man's activities that limit waterfowl horizons.

Regardless of source, there is plently of evidence—evidence admitted without question—that man limits the waterfowl horizons.

A discussion of how to control and offset man's inroads will carry us into the files of the Corps of Army Engineers, the plans of reclamation, flood control and hydro-electric projects—into plans for waterway transportation, into farming, ranching, drilling for oil, altogether an almost unbelievable list of activities.

Suggested remedies which primarily are plans to arrest these destructive activities are good as far as they go, but they are not enough.

Let's take a look at our situation, oversimplified for emphasis and for brevity.

Number one: We know the human population will increase.

Two: We can be reasonably sure that man in his endeavor to gain an easier living will want more of the land and water than he now uses and that he will be influenced more by short-term gains than by long-term effects.

Three: Men will continue to want to hunt, and will give up more and more to enjoy this sport.

Four: Lacking a continuing and increasing supply of young birds each year, man's encroachments will inevitably wear down the existing flocks. This has happened too often in the past to be ignored.

Finally, we can be sure Mother Nature and her waterfowl will change little. Therefore, any adjustments made will be made by man.

There will be more people, more hunting, fewer places for the waterfowl to live. We shall want more—not fewer—ducks. This spells one thing—greater production.

An industrialist, facing such a situation, would say—build new factories to increase *production* and also develop better methods and tools to increase the *productivity* of your present factories. Translated to our language, this means additional birds hatched on new breeding areas yet to be established and better management to increase the hatch on existing grounds.

Here man can be a stimulating factor on the waterfowl horizons. Fortunately, all the tools and techniques of the twentieth century are at his disposal. As they helped him destroy, so can they help him restore. We can be sure Mother Nature stands ready to help.

For the past 16 years an experiment in bettering the nesting grounds has been carried out in the Canadian prairie provinces. It has been successful. Wildlife flocks have increased. Do not misunderstand me. I do not claim all the credit for Ducks Unlimited. Many other activities contributed—some man-made—some natural. But I do contend its work has demonstrated a substantial increase can be obtained by assisting Nature to carry out her age-old processes.

The work has been extensive but not expensive. Scattered over the three prairie provinces, each one nearly as large as Texas, and in places distant from labor and material, it is remarkable for having done so much field work at an average annual expenditure of less than a quarter-million dollars. No land was purchased. The Canadians, their municipalities, or the Canadian provincial governments have furnished the land and have been generous in their cooperation. In many instances, they have paid from one to two-thirds of the cost of a project.

The field work falls into three categories: restoration, protection, and creation.

The Big Grass Marsh, about 100 miles northwest of Winnipeg, originally consisting of 104,000 acres of water and marsh, was a great nesting area for ducks and geese. Early in the century, an American syndicate spent about seven million dollars draining it and sold the land to settlers, who after building homes, discovered it unsuitable for agricultural purposes. One by one, they abandoned the land and eventually it reverted to the government for taxes.

Ducks Unlimited's initial field project was to install dams which eventually restored about 50,000 acres of marsh with over 40 miles of shoreline. The local municipalities made the land available and retained the fur rights. They have cooperated thoroughly with Ducks Unlimited during the intervening years and the restored marsh has proven a marvelous wildlife habitat—one of the most productive in all Manitoba and a good example of restoration work.

In the area around Brooks, Alberta, new breeding grounds were created. Surplus irrigation water was used to make many thousands of acres of new marsh, all excellent for duck production. In the spring, water is abundant and is little needed for irrigation. It is diverted without cost to build duck nesting grounds on what was once bald prairie.

Sometimes restoring and protecting the old grounds is combined with building of new. In the Peace River country of Alberta, located on a height of land interspersed with open wet muskeg and small lakes bordered by tall grasses, the Kimiwan and Winagami Lakes were noted as excellent duck producers. Together they covered an area of some 7,500 acres, but the drought years lowered the water levels severely and duck production suffered.

The government of Alberta and Ducks Unlimited joined in a project to dam the Heart River and divert some of its water into those lakes. Their original productivitly returned and additionally a new duck breeding ground equal in size to that of the original lakes will come into being when the reservoir fills.

I cannot overemphasize the great contributions made to this work by the Canadian governments, Canadian organizations, and individuals living in the area. Without their help, it could not have been successful.

What was done in Canada can be done in the United States. It can be done better, because the early mistakes can be avoided and the good work improved upon. There still is a great deal more work to be done in Canada but likewise, a great opportunity for the same kind of work in the breeding grounds of our northern border states, where old grounds can be restored and new ones created if simple grass-root measures are initiated and the support of local private interests is enlisted.

The second requirement follows the first naturally. The increased crops of waterfowl must be assured safety from wasteful loss during migration and on the wintering grounds, and should be harvested wisely. This can be done without destroying their aesthetic and economic values. It can be done in a way which will leave adequate breeding stock. But everything not required for these needs should be harvested annually. It is just as sinful to waste waterfowl production as it was to waste pig production.

It is important this be done because such a harvest will insure continuance of essential conservation work. The limited experience of the last decade clearly indicates that the interest of the hunter is one of the dominant reasons for the size of our present flocks. This interest should be encouraged to take up the work of improving and applying sound game management to the areas used by waterfowl after they leave the breeding grounds. Specifically, this means improvement of waste lands so as to afford food and shelter for birds, and sport for man.

Already some waste lands on the migratory routes have been cleared, crops planted, fields flooded. In other areas, reservoirs have been built and protected. In some few places, proper management on existing grounds has been sufficient to carry the birds. Enough work has been completed to point the way for more. Each bit helps to replace the old marshes.

It is an undertaking of vast proportions.

The gunners' purchase of duck stamps added some four and one-half million dollars to Fish and Wildlife funds last year and the excise taxes he has paid on shells and firearms and the state license fees have added many millions to conservation funds available to State and Federal Governments. Large though these sums are, they are not alone sufficient to make the necessary additions and furnish the management required

The government alone cannot do the job. A wide-flung undertaking of these proportions would be almost impossible to supervise and police. The building of refuges here and there through the migration routes will not be enough. Both government and private spending is called for. The government to furnish leadership and reasearch and to encourage the extensive use of private funds.

Even at that it will not be a cure-all. It can only buttress and strengthen other conservation measures. It has strength because it encourages man's constructive abilities rather than contents itself with restricting his destructive tendencies. Made up of the independent actions of thousands of individuals and groups of individuals, it will be stronger and more effective than a single over-all program directed from a central source.

The management of the area will be of equal importance with its restoration. The wildlife values of the marsh in back of Farmer Jones' farm, the holdings of an old-time ducking club, or the extensive areas of public shooting grounds can be quickly destroyed if not properly managed. Abused or carelessly handled, they cease to be a waterfowl asset and, once destroyed, are difficult to restore. Properly regulated, they will support flocks much larger than the present ones.

Man, the hunter, is the same man who farms. The same motivations affect him. The farmer would not be draining wet lands today if he expected to harvest smaller and smaller crops from them. By the same token, the hunter will not spend money to increase the waterfowl carrying capacity of wet waste lands if he does not see the prospect of an additional harvest.

This significant and encouraging passage appeared in a paper presented to a conference by a prominent conservationist last December:

> "Shortage of areas available for hunting has resulted for a number of years in an under-harvest of the major species of waterfowl along the Pacific Coast, particularly California.
> "Every effort must be made to make the extensive clubs and private holdings more productive and attractive to the birds."

Certainly there is nothing in today's picture to indicate man will not always be a limiting factor on the waterfowl horizons, but there is equally as much which points to his ingenuity and his imagination and his industry as offsetting factors. The important task of inducing him to use them to expand and widen those horizons lies before us.

DISCUSSION

DR. JULIUS KOWALSKI (Princeton, Illinois): I am just a small country doctor by profession, but a conservationalist by avocation. I happen to be a member of Ducks Unlimited and a few other conservation societies. I feel a few other remarks are needed in Dr. Gaylord's paper.

I happen to be a member of a duck club on the Illinois River, 125 miles southwest of Chicago and I can tell you what we have done. Our membership is limited to 50. We have harvested almost 4,000 ducks the past season with our membership of 50.

We have some 2,400 acres of river bottom land and during the past winter, we have kept perhaps 50,000 ducks on our grounds because it was not a particularly severe winter. Plenty of corn was available in all the machine-picked fields adjacent to the river banks. So, I think sportsmen's orangizations and groups are really interested and desirous of having good hunting by putting in sufficient brawn as well as money, and they can augment the efforts of the Federal Government, state organizations and also with the help of Ducks Unlimited and our other friends to the north, upon whom we must depend for our entire duck supply.

PHILOSOPHY OF WATERFOWL ABUNDANCE

LUDLOW GRISCOM

Chairman of the Board, National Audubon Society; Vice-President, American Ornithologists' Union, Cambridge, Massachusetts

In the year 1623 the Mayflower Pilgrim colonists passed an act or ordinance declaring that subject to the rights of private property, all shooting or hunting of game and fishing was free. Possession of game belongs to the taker, and not as in England to the owner of the property where the game was caught or bagged. It has been represented that this was due to the severe resentment at the great restriction of hunting to the poor and underprivileged in England, and the holders of large estates in New York and Virginia tried to get and enforce those ownership rights to game, but finally lost shortly after the Revolution. However this may be, such did in fact become the common law not only of the whole United States but also of the Dominion of Canada.

Now that three centuries have elapsed, we might cast a backward glance and appraise the results. To those really interested in hunting and game, nothing more disastrous than our common law could possibly have been imagined! Starting with a great continent, positively known to have been teeming with an incredible abundance and variety of game, it has been more wastefully, ruthlessly and rapidly exploited and reduced than ever before in the entire history of the world. Depending entirely upon the gloom and pessimism of the writer, experts have variously estimated that only two per cent to ten per cent of the original amount survies. Philosophically this is readily seen to be common sense. Every grown man must know that if hunting is open to everybody, a lot of people in the total population of two great countries are going to be greedy, wasteful, ruthless and selfish, and that the right kind of ethics will be low. The decrease of game in

North America is at least 98 per cent on the shoulders of the hunters. not hunters in the sporting sense, but lured on by an economic or commercial interest.

In my youth I became most interested in our waterfowl and made extended field trips to become familiar with as many species as possible. In 1907 when I first joined the Linnaean Society of New York, I could not meet a young man who had ever seen a baldpate or a pintail alive in New York. Sworn to secrecy, we had to take a special trip to see the wood duck alive. Then and for many years duck hunting was my favorite sport. At first my shooting privilege was twenty-five ducks a day for an open season from September 15 through April 15, and I have gradually seen it reduced to four to seven ducks daily for a 40 to 60-day period in the fall. While psychologically I resent it, intellectually I am forced to accept it for the following reasons.

A young, vigorous, and great country had been on the march for three centuries. The pioneering age had ended, the primeval forest had been cut down, the prairies and plains were becoming overgrazed, over one hundred million acres of marshes had been drained; rivers, lakes. and harbors were becoming polluted, and stock was being taken of our badly depleted game reserve. I am the only American ornithologist who has dared to say in print that the passenger pigeon would surely have become extinct even if never ruthlessly pursued by professional pigeon netters. Where are the necessary one hundred square miles of primeval mast forest left to keep a large colony alive in summer and winter? Similarly, while I deplore it as a naturalist, I am unable to visualize a herd of a million buffalo, happy and well nourished, anywhere in the prairie and plains states I know quite well! In my home state of Massachusetts, I accept the lack of bears, panthers, wolves, turkies and swans and do not believe that any amount of laws or game management will restore most of them to that area, and supply them with a living.

As a consequence, we passed through an Era of Protection from 1904-1915. Market gunning was stopped, spring shooting was abolished, hunting seasons were shortened, bag limits were reduced, and a closed season was put on scarce species, all designed to stop the rapid depletion of our continental supply of waterfowl. The Age of Protection caused a great decline in hunting pressure, and in my youth deprived many citizens of their means of getting a living, and Americans were not lacking who thought that if only you pass a good law, the Golden Age was just around the corner!

After twenty-five years of the Age of Protection we may well appraise the results. The Golden Age has most definitely not arrived. Thoughtful men are concerned about our waterfowl and their future, which is precisely what this Conference is about. My personal belief is that the rapid increase in tempo of our forgoing industrial civilization is the cause of the trouble. Our population has jumped in 45 years from 91.5 to 160 millions. New permanent homes were over one million in 1951, when there were over 6.7 million cars and trucks on the road as compared with 187,000 in 1910, plus an unknown number of miles of new or super highways constructed. This, I submit, adds up to an enormous amount of general disturbance and disruption of preferred habitat. Many good duck ponds in eastern Massachusetts have been ruined by it since written up by John C. Phillips in 1929.

What is going to happen when our population reaches two hundred million, and most certainly should it reach the expected three hundred million, the time involved being simple to figure out statistically? Several million citizens armed with better guns, and more powerful powder, are now being carried annually in over two million cars over a super network of highways to every possible place in the country where waterfowl still survive. Economically speaking, in my youth these people could not afford to do so; I could never afford to belong to a good duck club, much less lease a shooting pass. But nowadays, thanks to the blessings of our American way of life, the hunters *can* afford to take a week off, they *do* own a car and can, in fact, get to some good duck area. The only sour note that an old crab like me can strike in this Golden and Blessed Age is that there are nowhere nearly enough ducks left to go around! Moreover, there is still another paradox. Here we are, conservationists meeting together to preserve our waterfowl. Don't forget that we are paying the taxes on the vitally necessary Fish and Wildlife Refuges, the luxury taxes on equipment, the taxes on the super highways and the income taxes and wages that enable this horde of hunters to get to the duck marshes!

To tie in my opening paragraphs, let me give you some reminiscences of my own. I have often been in England, and in 1934 I happened to be one of the American Delegates to the Ornithological Congress at Oxford and was asked to sit in as a delegate at a meeting of the International Bird Protection Committee. Two weeks were than spent in the British Museum, where I met most of the Englishmen concerned, from whom I learned a few unpalatable truths. I was burned up to learn that in England spring shooting had been abolished in 1880, but was violently disapproved of and not enforced, that game could still be sold and there were no bag limits. As one Englishman, now head of the British Museum, put it to me most courteously, "You people wasted your game and wildlife worse in three hundred years than we did in one thousand, though you have recently done some remarkable and very dramatic things." In talking this over with the late Dr. John C. Phillips, a great sportsman and waterfowl expert, we agreed that the decisive factor was the difference in the common law of the two countries that in England limited the shooting privilege of most of the population.

Because of World War II, the economic collapse of England and the crushing and confiscatory taxes, both income and inheritance, the whole basis of life and game management in Great Britain has altered. The New Wild Birds Protection Act of 1939, repealing that of 1880, has real teeth in it, reminiscent of our own legislation. The great landed estates are being broken up, the old profession of game-keeper is on the verge of extinction, and we are now witnessing the rise of sanctuaries under the British Trust for Ornithology. No longer can the landed gentry protect rare birds at their own expense, out of their own pocket. Government has been forced to step in. But game can still be sold, and there are no bag limits! Moreover, just to be disagreeable, the system works. As anyone can see who chooses to read *British Birds* in five volumes, the monthly magazine by the same name, and the just-published historical work on the *Birds of Scotland* in two volumes, ducks and geese are rapidly increasing since 1900, and are spreading as breeding species over the whole of England and Scotland. The Bewick's swan, an arctic winter visitor, is the *only* waterfowl of western Europe that has markedly decreased since 1880. This, unhappily, is my testimony as an ornithologist, and I hope to be believed, when I say that as an American, I wish the situation were reversed. The moral of all this is that the game supply and its scientific management will always be subordinate to human affairs, laws and economic stresses and if one changes radically, so must the other.

I hold the following truth to be self evident: 1) Game and wildlife, just like money, is an asset or a privilege. If it is abused in days of prosperity, it is apt to be lost in days of adversity. 2) A squandered game resource, a huge industrial civilization, a steadily mounting population, and the utter impossibility of requiring and enforcing good ethics on everyone, represents a day of great adversity. 3) There is no way out; we must be rationed; the shooting privilege must be reduced, and we must somehow approximate the English common law system. If we are wrong, if we misjudge, then we will lose another very pleasant sport, and history will sadly repeat itself once more. I am not here to propose any particular program or action but, in line with the title, this is my philosophy based on a lifetime of study of both human nature and waterfowl.

Gentlemen, I wish you the best of good management, as well as good luck!

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PART II

TECHNICAL SESSIONS

TECHNICAL SESSIONS

Monday Afternoon—March 8

Chairman: RALPH F. HONESS
Biologist, Game and Fish Laboratory, University of Wyoming, Laramie, Wyoming

Discussion Leader: EUGENE P. ODUM
Associate Professor, Department of Biology, University of Georgia, Athens, Georgia

DISEASE, NUTRITION, AND CONTROLS

HUNTING AS A TECHNIQUE IN STUDYING LUNGWORM INFESTATIONS IN BIGHORN SHEEP

GILBERT N. HUNTER AND RICHARD E. PILLMORE
Colorado Game and Fish Department, Denver

Colorado is credited with having one of the largest Rocky Mountain bighorn populations in the United States. In 1952-53, a total of 3,991 sheep were actually counted in 115 separate herds (see Fig. 1 for distribution). Even though a heavy die-off was experienced in three large herds in 1952 and 1953, an estimated 5,000 mountain sheep still remain in the state.

DISEASE BACKGROUND

The loss that occurred in the three herds was attributed indirectly to lungworm infestation. In the Tarryall region, located in South Park approximately 100 miles southwest of Denver, 376 dead sheep were found by Department personnel in 1952 and 1953. In the Kenosha area, adjoining the Tarryall Range, 66 dead sheep were found; and to the south of these areas, near Pikes Peak, 57 dead sheep were found. All the above are within the same general locality. It is believed that the counted loss represents only a small part of the actual loss, which probably involved about two-thirds of all the animals in the three herds in question. Prior to this loss, the estimated population of these herds was approximately 1,500 animals.

This trend is not unusual for Colorado, as early records indicate losses as early as 1859, 1885, 1903, 1923 (Cary, 1902; Seton, 1927; Carhart, 1938; Spencer, 1943; Packard, 1946). These earlier losses were attributed to scabies and hemorrhagic septicemia, and it was not until 1931 that the lungworm was identified as a factor in the decline of Colorado sheep (Dickmans, 1931). Naturally, these periods of decline cannot be pin-pointed to a particular year, since studies indicate that they may have continued over at least a 10-year period. Reports of early writers are contradictory, though it would appear that the dates mentioned represent the years in which the heaviest losses probably occurred.

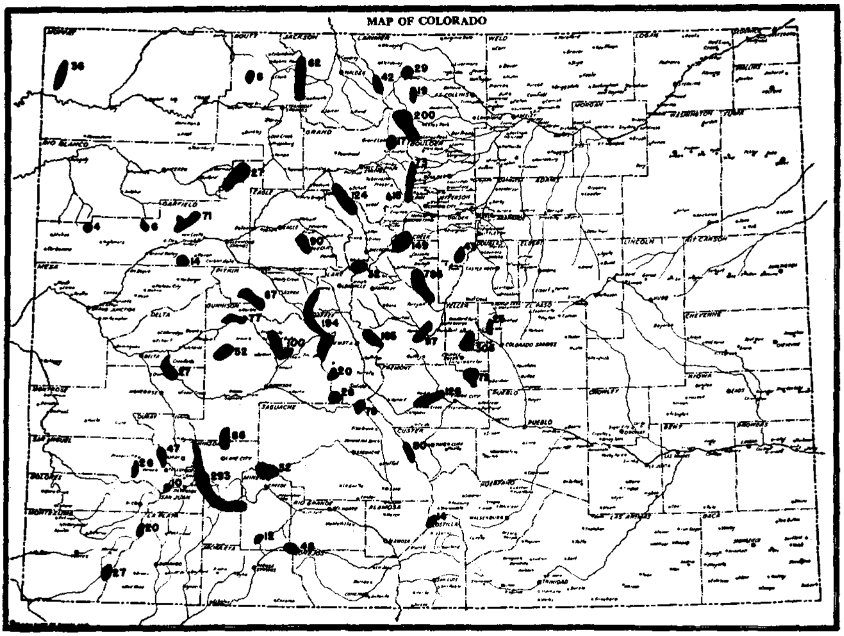

Figure 1. Distribution and actual count (3,991) Rocky Mountain bighorn sheep. Colorado, 1952.

History indicates that the rise and fall of Rocky Mountain bighorn herds has followed a fairly definite pattern, rising to a peak population then declining to a low; and these peaks and lows are approximately 10 to 30 years apart (Rush, 1928; Marsh, 1939; Honess and Frost, 1942).

In analyzing the early sheep die-offs, it is our opinion that even though they were attributed to hemorrhagic septicemia and scabies, the losses may have been caused indirectly by lungworm. Symptoms described, such as rough coat, nasal discharge, coughing, uncertain gait, and a pneumonic condition, are similar to those now known to accompany a heavy lungworm infestation. Lungworm is now accepted in Colorado as one of the important factors in the decline of our sheep herds, and apparently has always been. Verminous pneumonia losses, approaching epidemic proportions, have only been observed in three herds; however, the information gained from the hunt in September, 1953, would indicate that probably most of our bands are infested with this parasite. The presence of lungworm was detected in 13 of the 14 areas where sheep were killed in 1953 (Table 2).

DESIGN AND OPERATION OF HUNT

Nine years ago the Game Management Division of the Colorado Game and Fish Department realized that action should be taken to manage our bighorn sheep herds properly and, through the Director and the Commission, administrators were successful on March 3, 1945, in getting the Legislature to establish a resident bighorn license. Getting the license established was merely the start of the battle for good game management of our herds, as a season was opposed by the public as well as some Department personnel.

Prior to the setting of a season, the department concentrated its efforts to gain public support. This effort was made before there was any knowledge of disease loss, and the primary reason then given in justification was to harvest surplus rams. Such a harvest, it was argued, would better balance the sex-ratio, thereby increasing productivity of the herds. When it became evident that three of Colorado's major herds were sustaining serious disease losses, overcrowding was stressed as a major factor in disease spread. In all cases examined, these losses were attributed to verminous pneumonia. The importance of determining the degree of infestation in other herds by obtaining specimen material through hunting was also emphasized. The Colorado Game and Fish Commission, in 1953, thus set a season in 18 sheep areas, and issued 169 licenses for rams with one-half-curl horns or better. This number was predicated on a hunting success ratio of 33 per cent. The dates of September 3 to 13, inclusive, were selected because the sheep are then in the high country and well scattered. Furthermore, good weather, which can generally be expected at this time, would directly benefit the hunter. This time was decided upon even though the pelage was too short for the best trophies.

The season in 1953 was the first since 1885, and as soon as the opening was announced it aroused one of the liveliest controversies that the game department has experienced in many years. The opposition was led by one of the largest Denver newspapers, purely for sentimental reasons; and as a result, all sentimentalists and persons having a complaint against the Department flocked to its support. The controversy became so heated that it was carried to the governor and a group of influential legislators in an effort to stop the season. Threats were even made that if the season was held the Department would suffer materially when the next appropriation was made. Sportsmen throughout the state, however, due to a very effective educational program, were strong in their support of the Department. As a result, the commission stood firm and accepted the recommendations of the field men.

As previously stated, the primary objectives of the season were: (1) to improve the sex-ratio; (2) to ascertain the extent and intensity of the lungworm infestation; and (3) to relieve concentration. Two of these objectives were accomplished to a degree, as the hunters were very cooperative, and lung samples were obtained from every area in which sheep were harvested. Naturally the removal of a limited number of rams was a benefit, since the sex-ratio prior to the season was about one-to-one in all herds.

Originally it was planned to remove a specific number of rams from each herd. This number varied from 20 to 60 per cent. Had this been possible, an excellent study could then have been conducted as to the most desirable sex-ratio. Due to the controversy over the season, it was thought good policy to reduce the number taken the first year, and work towards this objective in the seasons to follow.

The third objective, relief of concentration, did not materialize as the number of hunters in the field was too small to cause a permanent movement of the sheep.

Prior to the sheep season, the Department concentrated on an educational program primarily to inform sportsmen that sheep hunting was very difficult and expensive. Hunters not in good health, or not thoroughly versed in woodcraft, were advised not to apply for a license. The result of this program was very gratifying, as only 237 persons applied, even though every resident in Colorado was eligible. All applicants were required to send a certified check or money order in the amount of $25 with their application. As applications were received, an IBM card was key-punched, and the 169 successful applicants were chosen mechanically by the IBM statistical machine. Successful applicants were generally of a high calibre and later proved themselves to be good sportsmen.

As this was the first sheep season in Colorado in 68 years, the hunt was strictly supervised. Base camps for Department personnel were established in every hunting area, and as experienced sheep hunters were exceptions, State men were instructed to assist them in every possible way. Seventy-one Department men were assigned, and ranged in number from three to five to each camp. Before the season, all men were instructed as to the manner in which lung tissue, bile duct, and stomach samples should be taken. As a result, usable samples from 47 sheep were obtained. Another factor which enabled the state to gain more information regarding the condition of the sheep was the regulation which required all animals to be checked by Department personnel.

All successful applicants were sent a personal letter of instructions as to how the base camp could be reached, the names of packers and guides in the area, and what in the way of specimens the Department desired. A few tips on how to hunt bighorns, equipment needed, and probable success that could be expected, were included in the letter. The favorable results of this personal touch were reflected in answers to a questionnaire which was sent the hunters after the season, and which will be discussed later.

Since one successful applicant was unable to hunt, the 168 hunters killed 58 rams, for a success ratio of 34.5 per cent. One violation occurred, as a lamb was shot by mistake; and seven animals were wounded and not obtained. Practically all hunters reported the sheep difficult to find. This fact was gratifying to the Department, as the opponents of the season made an issue of the "tame" sheep that would be "slaughtered"; hunter reaction, however, definitely disproved this theory.

Following the season, the Department, in order to gain knowledge of hunter reaction, sent questionnaires to the 169 successful applicants. It was felt that information such as we expected to receive would be valuable in setting future sheep seasons. The response was very good, and 144, or 85 per cent, of the hunters returned their completed questionnaires.

The results of this survey are given in Table 1. In Table 2, the caption, "Number of sheep seen by," was recorded both by wardens and hunters, which explains the discrepancy in numbers. In the warden count, duplication has been eliminated, and hence represents the most accurate figure. It will be noted that in both counts the number of ewes and lambs far outnumber the rams. It is our opinion that this is not entirely true, and it must be remembered that Colorado bighorns have not been hunted for 68 years, and field studies show approximately a one-to-one sex-ratio. Apparently there were many more rams in the areas than were seen.

It is also interesting to note that only 7 per cent of the hunters reported that they were not pleased with the hunt (Table 1). Naturally

TABLE 1. SUMMARY OF BIGHORN SHEEP QUESTIONNAIRE (144 HUNTERS REPORTING)

Did not hunt	Kill reported		Days Hunted	Sheep seen per hunter		Did you get a shot at a bighorn sheep?		Where was Kill made?		Where were most sheep seen?		Sheep hunting, Compared to Elk		
	Yes	No		Rams	Other	Yes	No	Above Timberline	In Timber	Above Timberline	In Timber	More Difficult	Same	Less
1	56	88	729	525	1,684	66	78	43	13	80	38	111	19	10
			5.06	3.65%	11.69%	45%	54%	76.79%	23.21%	67.80%	32.20%	79.28%	13.57%	7.15%

Were horses used?				Rifles used by successful hunters		Guides used		If guide used, was service satisfactory?		Were you satisfied with this season?	
Owned	Borrowed	Hired	Didn't use	Calibre	No. hunters reporting	Yes	No	Yes	No	Yes	No
43	11	58	27	.300 Sav.	6	13	131	11	2	134	10
				.30-06	25						
30.94%	7.91%	41.73%	19.42%	.300 Mag.	4	9.03%	90.97%	84%	16%	93%	7%
				7MM	4						
				.270	12						
				.30-40	1						
				8MM	1						
				.348	2						
				.30-30	1						
					56						

TABLE 2. BIGHORN LICENSE SALES: KILL: LUNGS SAMPLES; NUMBER OF ANIMALS SEEN, COLORADA, 1953

Bighorn hunting areas						Number of sheep seen by					
						Wardens			Hunters		
No.	Name	Licenses Sold	Legal Kill	Lungs Sampled	*Positive evidence of Lungworm found	Rams	Ewes, Lambs	Unclassified	Rams	Ewes, Lambs	Unclassified
1	Poudre	5	2	2	2	10	9		13	9	
2	Clark's Peak	5	3	2	2	22	13		15	17	2
3	Gore Range	10	0	0	0	4	3		2	6	
4	Georgetown	10	3	2	1	22	46		41	78	
5	Mt. Evans	5	0	0	0	3	63		0	89	
6	Grant	5	1	0	0	6	32		6	108	
7	Kenosha	15	7	4	3	18	18		23	42	
8	Tarryall	25	1	0	0	12	31	42	7	69	
9	Pikes Peak	10	6	6	5	30	28		50	1	6
10	Lower Arkansas	10	8	7	0	32	96		132	259	
11	Cottonwood	10	3	2	2	14	17		34	46	
12	Crestone	10	5	3	3	25	35		57	289	
13	Taylor	7	4	3	3	11	3		23	0	
14	Sopris	5	0	0	0	0	19		0	41	
15	Glenwood	7	2	2	2	4	20		15	45	
16	Pole Mountain	10	4	4	4	14	22		21	52	
**17	Cimarron	10	0	1	1	6	36		0	100	
18	Buffalo Peaks	10	9	9	9	32	153		86	425	
	Totals	169	58	47	37	265	612	42	525	1,676	8

*Identification by Dr. Lynn A. Griner.
**1 Illegal kill.

the men comprising this seven per cent, unsuccessful in the field, were in areas where hunting was difficult. Even so, complaints in the amount of 7 per cent are small when it is considered that 66 per cent of the hunters were unsuccessful.

One other question, not shown in Table 1, referred to cost to the hunter. This averaged $203.66 per man, plus the $25 license fee, or a total of $228.66. A further analysis showed that 71.4 per cent of the successful hunters used horses.

Prior to the season it was thought that some record heads would be taken. This did not prove to be true, but measurements of three of the largest heads are given below. All measurements were made by Department personnel.

Horn circumference		Outside Curve		
Right	Left	Right	Left	Spread
14½	14¾	34	36	21½
15½	15½	36	31½	23½
15¾	15¾	34½	34½	21¾

ROLE OF HUNTING IN MANAGEMENT

Hunting appears to be the best method of alleviating overcrowding in bighorn populations; but how effective this tool is in dispersing the sheep over a wide range remains to be seen. Certainly, adjacent unoccupied range suitable for sheep is a major factor; also, whether or not the factors responsible for present concentrations are the result of habit or some environmental requirements must be considered. If hunting pressure is effective in moving sheep, then great care must be taken to assure that it is spreading them out and not concentrating them in smaller, more inaccessible, areas. If no suitable adjacent range is available, and the population is limited by this factor, then the problem is one of manipulating the size of the population through harvest of all surplus animals; or a combination of harvest and control may achieve the desired result. Determination of safe carrying capacity for a given range is difficult, and the manager may have to resort to trial and error in attaining the most satisfactory level.

The use of the hunting season in obtaining study material was emphasized to gain support for the bighorn season, and much can be said for, as well as against, this technique. Obviously, success in obtaining tissue samples is dependent upon the cooperation of both field personnel and the hunters, and to obtain this cooperation these men must have some understanding of the problems being studied. For example, they must know precisely what material is needed and how to obtain and preserve it; and they must be provided with the necessary equipment. Past experience has indicated that the amount of return is also dependent on the type of hunter, and the accessibility and roughness of the terrain.

The greatest advantage in employing the hunting season as an opportunity for obtaining study material lies in the relatively large sample which can be obtained in a short time from widely distributed areas. The taking of large samples by other means might arouse public animosity. Another value lies in the fact that it does carry some weight in gaining support of the public, when followed up with a report on the results obtained. However, it does not give the information which can be obtained by a trained man with the whole carcass at his disposal.

We believe that personal contact with the hunter before he starts his hunting is very important in getting his cooperation. To be able to explain what you want to the hunter is far more certain than expecting him to get it from a handful of literature which he may or may not read, though printed instructions, in addition to personal explanation, are desirable. It is also important to require that any animal bagged be checked by game department personnel before leaving the hunting area.

Probably the greatest disadvantage, other than the fact that it does not supply everything that could be desired (the whole carcass), is that additional control is necessary, which increases the cost of operating the hunting season.

LUNGWORM STUDIES

Obviously, all of the information needed for managing bighorn sheep in Colorado cannot be obtained by permitting a season and collecting study materials from the animals killed. Studies are needed to provide information on the status of individual herds, their productivity, and other factors which control their increase and decrease.

The Federal Aid Division of the Colorado Game and Fish Department has undertaken these studies in its bighorn sheep project. Part of these studies involve the investigation of the life-history and ecology of the lung nematodes of bighorn sheep. There are two species of lungworms known in Colorado—*Protostrongylus stilesi,* which is regarded as being pathogenic (Marsh, 1938; Honess, 1942), and *P. rushi,* which is much less pathogenic (Honess, 1942).

These studies cannot be conducted on a state-wide basis with the hope of accomplishing very much; consequently, the Pikes Peak region, since it was the type locality for *Protostrongylus stilesi,* as well as an area sustaining heavy losses, was selected as one study area.

Most of the preliminary work on the life-cycle of these parasites has been confined to this region.

We hoped to obtain information on the incidence and degree of infestation in the other herds of mountain sheep, and with this information, select other strategic areas for study. Two such areas have been selected on the basis of information obtained as a result of the hunting season, summarized in Table 2. The area north of the Arkansas River, between the towns of Parkdale and Cotopaxi, was selected because none of the lung samples obtained here during the season showed any evidence of lungworm infestation. The Buffalo Peaks area, farther up the Arkansas River drainage, was selected, on the other hand, because all of the lung samples obtained here were infested.

Preliminary investigations indicated that the life-cycle of *P. stilesi* and *P. rushi* followed the same general pattern as reported for related species (sub-family: Protostrongylinae) by Hobmaier and Hobmaier (1930), and other subsequent authors. The life-cycles of these lung nematodes may be summarized as follows: eggs, laid by the females within the lungs, hatch, giving rise to first-stage larvae. These migrate up the trachea to the region of the throat, where they may be swallowed and then pass out of the animal in the feces, or possibly leave the animal in respiratory discharges. In order to reinfect the host animal, the first-stage larvae must penetrate the tissues of a suitable intermediate host which, in all cases so far investigated, have been pulmonate snails. Within these snails they reach the infective stage by an increase in size followed by two cuticular molts. The shed cuticles form a sheath or case about the larvae. Completion of the cycle is dependent upon the ingestion, by the host (sheep), of the infected snail. Infective larvae are released from the tissues of the snail by digestive processes, or possibly through mastication, whereupon they may penetrate the intestinal walls and make their way to the lungs via the lymphatics and blood vessels.

To date, only *Pupilla blandi, P. muscorum* and possibly *P. hebes,* have been found, by experimental infection, to be suitable intermediate hosts for the protostrongylid larvae obtained from the droppings of Pikes Peak sheep. Although several hundred snails have been examined from this range, only one instance of naturally infected snails has been noted. This was in *P. blandi* (Moser and Pillmore, 1954), collected about the bases of tufted-hair grass (*Deschampsia caespitosa*). It may be of interest that these snails were found on a west-facing slope below a rocky outcropping on which sheep sign was evident.

It is well known that susceptibility to parasitic infestation varies with individuals of the same species, and that this resistance to parasites seems to be associated with factors such as age, state of nutrition, kind and number of parasites already present, and other factors. The degree of infestation in susceptible host animals is determined by the number of infective larvae picked up. Large numbers of infective larvae taken over a short period of time may also help to break down resistance to infection. The effect of lungworms upon the bighorn sheep is probably largely dependent on the degree of infestation. This, in turn, is a manifestation of crowding, where climatic and other conditions, including the presence of intermediate hosts, favor the survival, development, and transmission of the larval stages of these parasites.

The cause of death in the more recent losses has been attributed to pneumonia or hemorrhagic septicemia, while those of the late 1800's and early 1900's were thought to have been associated with scabies or psoroptic mange.

Investigations on the three study areas already mentioned are designed to evaluate density and distribution of the snail as the intermediate host, in relation to the density, distribution, and habits of bighorn sheep.

Factors which control the density of sheep and snails will also be studied. It seems that in the case of bighorn sheep, the usual determination of carrying capacity on the basis of the quantity and quality of available forage is inadequate, and other factors controlling sheep density may be of greater importance in determining the carrying capacity of a particular range. Certainly if a good dispersion of environmental requirements exists there is little necessity for crowding, unless it is a gregarious habit. In future bighorn sheep seasons, much attention will be devoted to planning so as to obtain as much information as is possible from the animals taken. Since there is apparently a difference in pathogenicity between *Protostrongylus stilesi* and *P. rushi,* information is needed as to which species is present, or whether both occur in combination. It is also important to determine the degree of infestation. If preliminary life-cycle investigations of these parasites involve first-stage larvae of both, it then appears that the larvae of the two species are indistinguishable. Some information on the kind, number, and pathogenicity of other parasites would be of value. Perhaps fecal-sample analysis would be the simplest approach. Formalin seems to be about the best preservative for this type of work, but it is difficult to find suitable containers, for neither cardboard nor glass is very satisfactory. Some type of metal or a non-brittle plastic, however, may be suitable. One of the field men had excellent success by issuing plastic bags to the hunters, then preserving the material in formalin when they returned to camp.

Certainly the information obtained by questionnaire and hunter report cards is always useful to management. This hunter and hunting information, together with laboratory and ecological studies, should make for better management of the bighorn resource in Colorado.

SUMMARY

1. During 1952-53, serious disease losses (involving about two-thirds of all sheep present), occurred in three Colorado bighorn sheep herds.
2. This represents about the third major decline for which there is some record.
3. These declines have been attributed to scabies, hemorrhagic septicemia, and for the more recent decline, verminous pneumonia.
4. A limited bighorn sheep season, the first since 1885, was held in Colorado during September, 1953, in spite of some bitter opposition to such a season.
5. Much of the success of the season may be attributed to personal explanation and written instructions given each hunter.
6. One hundred and sixty-nine licenses, for the taking of bighorn rams of more than one-half curl, were selected from 237 applicants by an IBM machine. Of these, 58 killed rams, for a success ratio of 34.5%.
7. The species of lungworm involved in the diagnosis of verminous pneumonia as the cause of decimation is *P. stilesi;* although a less pathogenic species, *P. rushi,* is known to occur in Colorado.
8. Out of 18 areas in the state open to hunting, lung tissue samples were obtained from 14, and in 13 of these areas there was evidence of lungworm infestation.
9. Preliminary investigations indicate that the snails (*Pupilla blandi* and *P. muscorum*) are suitable intermediate hosts for protostrongylid larvae, obtained from droppings of bighorn sheep in the Pikes Peak area.
10. It is suspected that sheep density, as a major factor in the spread of parasites and disease, is of great importance in producing periodic declines. Studies of the relationship between, and the factors affecting the density, distribution, and habits of snail as the intermediate hosts, and bighorn sheep as definitive hosts for lungworm, are planned. Three study areas have been selected, largely on the basis of information gained as a result of the hunting season.

ACKNOWLEDGMENTS

We are indebted to the Colorado Game and Fish Commission, and the Director of the Colorado Game and Fish Department, Thomas L. Kimball, who made this 1953 bighorn sheep season possible; to all field men assigned to the bighorn hunt, whose efforts did much to make this season a success; to Dr. Lynn A. Griner, Pathologist for the School of Veterinary Medicine; and to Dr. O. Wilford Olsen, Head of the Department of Zoologly, Colorado A & M College, for their diagnoses and identifications.

To all sheep hunters whose excellent cooperation did much to help the Department.

To Dr. Lee E. Yeager, Leader, Colorado Cooperative Wildlife Research Unit, who read the manuscript and offered constructive criticisms for its improvement.

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DISCUSSION

DISCUSSION LEADER ODOM: I might, just to get started here, make a little comment. This is a population oscillation over 10 years that he is describing here, and I would like to see the fundamental question of cause and effect discussed. In other words, does the population high result in the parasitism, or is the parasitism causing the population to be unnecessarily low? I know people here have had similar experience with other big game.

MR. ROBERT F. SCOTT (U. S. Fish and Wildlife Service, Fairbanks, Alaska): I would like to ask Mr. Hunter, in line with the Chairman's suggestions, two questions. First, What were the ages of the animals which were found dead? What was the distribution of the ages of the dead animals? And secondly, will you define a decline in productivity?

MR. HUNTER: Mr. Scott, in answer to your first question, relative to ages, it makes no difference. The animals we have actually found are lambs, ewes and rams. It makes absolutely no difference.

MR. SCOTT: Did you find the decline in productivity accompanying this overcrowding as it became more and more apparent?

MR. HUNTER: Frankly, we can't answer that at this time. Our field men have not come forth with that particular point of our problem. They are now studying it to see if there is any effect.

I should point out one thing. I think it is important to you game managers and biologists. The one herd where we did not find infestation—now I don't say it was not there—is on the poorest range we have for all the herds. It happened to be the Arkansas-Kansas herd where our range is in terrible shape. There we found no lungworm. Maybe it is too dry. I don't know if Arizona and California have lungworm infestations. That possibly can be attributed to the place of the snail in the cycle. I don't know.

But, in our driest, poorest range, we found no lungworm in our sheep. So, you can take that for what it is worth.

DISCUSSION LEADER ODOM: Would anybody else like to contribute to this interesting and important problem? I know there have been some similar studies in the Southwest and in Wyoming. Is. Mr. Bagley here? He had some information on that.

MR. LESTER BAGLEY (Wyoming Game and Fish Commission, Cheyenne): I am present, but I would like Mr. Honess to discuss that phase of it for Wyoming, please.

CHAIRMAN HONESS: Years ago we spent considerable time in studying bighorn sheep, particularly in the Jackson Hole area, and since that time, there has been little done. What we did and what has been done in recent years is to collect droppings from bighorn sheep on various ranges and by an examination of the droppings, determine if lungworm larvae are present.

Now, insofar as I can remember, all of the flocks we have investigated in Wyoming have some members that are infected with lungworms. What part the lungworm has in the failure of some of our flocks to increase in numbers, I don't know. I couldn't answer that.

DISCUSSION LEADER ODOM: Does anybody else have a comment? I mentioned the importance of what I termed the cause and effect; I realize it can't be answered now, but perhaps in the future, if the lungworm is the result of overpopulation, then of course the thing to do is prevent the overpopulation and not worry too much about the lungworm. But, if the lungworm is causing underpopulation, then of course, the lungworm itself or any other disease or parasite that may occur is of first importance. That would be the result of our thinking in those terms. It depends entirely as to how you proceed in the future as to which of those things is actually the case. Does anybody want to disagree with me or otherwise comment?

MR. THOMAS L. KIMBALL (Colorado Game and Fish Department, Denver, Colorado): I think it might be well to bring out that lungworm in itself actually didn't cause the death of these animals. At least, that is what we think. You have to have a constant reinfection and a load of lungworms in the lungs of the animal, in the tissue itself, to bring about pneumonia, which is probably the actual cause of death.

Now, we suspect, although we are not able to prove it at the present time, that concentrations are responsible for constant reinfection that brings about this eventual pneumonia, and although we are not in a position to prove it as of now, I think as time goes on and more studies are completed, our position on that will be confirmed.

DISCUSSION LEADER ODOM: Would you like to comment on that, Mr. Hunter?

MR. HUNTER: Well, actually the direct cause of death as diagnosed by Dr. Griner was verminous pneumonia.

There is one other point I think you game administrators may qualify. We make mistakes, we know, but I want to bring out a few points. There was a little complaint that there weren't many rams in the country. In other words, I will try to quote some figures as I remember them. But, we said this, every man that went in there, we asked him to keep track of the sheep he had seen, particularly the rams, ewes and lambs. Of course, we had to lump the ewes and lamps together. But, we also told our own personnel to keep track and try to eliminate all duplication.

Well, the hunters came out with something like five to six hundred rams seen in these 18 areas, and approximately 1700 ewes and lambs.

Our wardens came out with, I think, 265 rams compared to 600 and some. But, here is the point I am trying to drive home, that after we hadn't hunted sheep for 68 years there were just as many rams in all probability there as there were ewes and lambs.

Incidentally, our cooperation from the hunters was excellent. I think you have to make them a part of the team. When the hunter realizes that he is helping a game and fish department get certain information, he is going right down the line with them, and it is very gratifying to see that type of cooperation come from our hunting public.

INVESTIGATION OF FOX POPULATIONS AND SYLVATIC RABIES IN THE SOUTHEAST

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The importance of rabies in wildlife populations has been emphasized only recently even though its severity has been noted in several parts of the country from the epizootic of 1812 to the present (Gier, 1948).

Much effort has been put forth during the past few years to control the disease in fox populations; but in spite of these efforts, it has become enzootic in some areas and is yet spreading to areas where the wildlife was apparently unaffected before.

Since it is realized that more basic knowledge is needed as a basis of control, the present study is designed to gather data on the epizootiology of the disease through an ecological investigation of fox populations.

ACKNOWLEDGMENTS

This study is a contribution of the Division of Vertebrate Ecology of The Johns Hopkins University and supported in part by a grant from the National Institute of Health of the Public Health Service.

The author wishes to express his personal thanks for help received from the following persons. Dr. James E. Scatterday, public health veterinarian of the State of Florida, and Dr. L. E. Starr, public

health veterinarian of the State of Georgia, made available state rabies records and sent out notifications of new outbreaks of the disease. Mr. Ralph H. Allen, Jr., biologist-in-charge, State Game Management Section, Alabama Department of Conservation, gave information on wildlife rabies in his state. Mr. Joe Stringer, trapper, put in many diligent hours in the field. The personnel of the Thomasville Field Station, Communicable Disease Center, Public Health Service, made available their facilities.

EXTENT AND DISTRIBUTION OF SYLVATIC RABIES

A study was made of the records of the Georgia, Florida, and Alabama Departments of Health for the history of sylvatic rabies, and the occurrence of positive diagnoses was charted by date and county.

It is realized that these reports do not give a complete record of the occurrence of rabies, for it is common practice to dispose of suspected animals if no persons or domestic animals are exposed. It is possible from these records to determine distribution of the disease by counties, severity of the outbreak, seasonal trends, relative abundance between years, and annual endemicity. They also give an indication of the relative importance of species involved and the areas that have not been plagued.

For Alabama, only the incomplete records of the State Game Department were examined. These included all cases of sylvatic rabies diagnosed by the Alabama Public Health Laboratories for the years 1947, '48, '49, and '51. In Georgia and Florida the complete records were perused from the time of its discovery through November 1953.

In Georgia, sylvatic rabies was first recorded in Evans County on August 23, 1939. No further cases were reported in the state until June, 1940, when the first epizootic of rabies in foxes was discovered in Burke County. Johnson (1945) discussed the first recognized epizootic of rabies in the fox populations of Georgia, but no satisfactory explanation has been given for the absence of epizootics in years previous.

During the past 15 years, 1201 rabid foxes have been diagnosed by the Georgia Laboratories (Table 1). During this period it was reported in three skunks, five bobcats, and one raccoon. Forty-one counties in the state have not reported the disease. This can possibly be attributed to poor reporting in Chandler and Clay Counties, which have had the disease on all borders. With few exceptions, all of the counties of the northern Blue Ridge and Appalachian Mountain Valley Regions and the Coastal, Satillo, and Okefenokee Plains Regions

TABLE 1. LABORATORY CONFIRMED CASES OF SYLVATIC RABIES IN GEORGIA.

Year	No. of counties involved	Foxes	Other wild species
1939	1	1	
1940	18	127	1[2]
1941	18	31	
1942	4	5	
1943	6	9	
1944	20	59	1[3]
1945	28	178	1[3]-4[4]
1946	48	264	1[2]
1947	34	67	3[3]
1948	31	74	
1949	33	102	
1950	33	53	
1951	24	57	
1952	33	99	
1953[1]	22	75	1[2]

[1]Through November.
[2]Skunk.
[3]Bobcat.
[4]Raccoon.

have not recognized or reported it. Since practically all of the counties of these two large areas have not reported its presence, it seems reasonable to assume that it has not reached these counties. If the recorded distribution is correct, it would be worthwhile to investigate the ecological barriers preventing the spread of the disease into these areas.

Reports from certain Georgia counties indicate a high endemicity of rabies in the fox populations. Table 2 gives the percentage of years that rabies has been recorded since its discovery in certain counties. Of the 118 counties reporting the disease, 104 have had at least a five-year history. In 21 counties rabies has occurred in at least half the years. These counties are grouped into three areas. The largest contains 17 counties (11 with 50 to 60 per cent, 4 with 60 to 70 per cent, and 2 with 70 to 85 per cent annual occurrence) and occupies the central and western section of the Piedmont Plateau Region. The other two areas contain two counties each and are in the Dougherty Plains Region of southwest and the Altamaha Uplands Region of south-central Georgia. The remaining 97 counties report rabies less frequently and 53 of these have reported it in only one or two years.

The history of sylvatic rabies in Florida is less spectacular than that in Georgia. The disease was first reported in 1942, and since then 49 positive foxes have been recorded from 10 counties. None was reported during 1943, '45, '46, '49, and '50. Rabies was found among the Florida raccoons in 1947, and since then there have been 28 diagnosed from 13 counties. The disease has also been found in five skunks and seven bats.

The occurrence among the species involved is worthy of note. The disease tends to show a host specificity which may possibly be an ecological phenomenon. No fox has ever been recorded rabid in a county that has ever had the disease in its raccoons. In three counties, raccoons are the only animals known to have had the disease; but in eight others, dogs were also involved. The disease in raccoons is restricted to counties in the northern half of the peninsula. Eight of the 10 counties reporting the disease in foxes are on the mainland, and, in five of these, only foxes have been involved.

Rabies in raccoons has a high endemicity in two adjoining counties. Hillsborough County has reported rabies in four out of six years and Pinellas County has reported it in four out of five years.

In Alabama, during four years, 277 rabid foxes and 1 rabid bobcat were recorded from 35 counties. These data show three areas with a frequent occurrence, two of which are continuous with the areas of high endemicity of Georgia. In the Dougherty Plains Region, Houston and Dale Counties reported rabies every year and Henry County reported it three out of four years. The Piedmont counties of Chambers and Lee reported the disease in two out of four years. Franklin County of the northwestern short-leaf pine belt had indications in three years.

EFFECTS OF CONTROL

The most satisfactory system used in Georgia to control rabies in foxes is the cooperative trapping program in which the U. S. Fish and

TABLE 2. THE OCCURRENCE OF SYLVATIC RABIES IN GEORGIA OOUNTIES. THE ONLY COUNTIES INCLUDED ARE THOSE IN WHICH THE DISEASE HAS AT LEAST A FIVE-YEAR HISTORY AND OCCURRED AT LEAST HALF THE YEARS.

County	Years since discovery	No. of years present	% of years present
Bibb	10	6	60
Clark	6	3	50
Decatur	8	5	63
Dodge	10	7	70
Early	13	7	54
Fayette	5	3	60
Harris	8	4	50
Henry	7	6	86
Jasper	8	4	50
Marion	10	5	50
Meriwether	8	4	50
Monroe	10	5	50
Muscogee	9	5	56
Newton	8	5	63
Peach	8	4	50
Schley	9	5	56
Sumter	9	6	67
Terrell	8	4	50
Toombs	8	4	50
Troup	7	4	57
Upson	8	6	75

Wildlife Service provides technical assistance and gives demonstrations; the state agencies provide part of the traps; and the county finances the remainder of the program and provides a man to distribute and collect traps and otherwise assist in the program.

The idea involved in a control program in an epizootic area is sound if the objective is to give immediate relief to the infected area; for if a population is reduced below the contact rate required for an epizootic, the disease will be abated and its spread retarded.

Whitehead (1953) reported that from 1946 through 1952 the U. S. Fish and Wildlife Service cooperated in control programs and brought the disease under control in 79 Georgia counties. By these programs, 14,720 foxes were removed from infected populations. Twenty-one programs have been in counties where the disease has a high endemicity (over 60 per cent of years); eight of these counties have had two or more annual programs and three have had three programs. Eleven of the 24 counties with frequent occurrence (50 to 60 per cent) have had these programs and five have had two or more. Eight of the 17 counties with lower occurrence (40 to 50 per cent) have also had cooperative control programs.

The disease has recurred in many of the counties which have had cooperative programs. This suggests that control by population reduction is a temporary measure, but its immediate effects should not be overlooked, for these programs have relieved epizootic areas and in so doing undoubtedly have slowed down or stopped its spread into new areas.

FOX POPULATIONS

Epidemiological theories express the idea that epidemics of infectious disease erupt in proportion to the amount of contact among individuals. The present study is investigating populations to determine the effects of contact rates among foxes in the spread of rabies and its eruption into an epizootic. With this in mind, a sampling method was developed whereby a density-contact index can be obtained and compared with indices acquired in other areas or in other seasons.

The index obtained from a population by a trapped sample has seasonal variation. Consequently, if used only as an index of population numbers, the data should be treated by seasons and comparisons made only under similar circumstances. The present investigation suggests, however, that it is not numbers alone that affectes the seasonal variation. In most of the cold-weather samples, the number of young added to the population was insufficient to compensate for the seasonal variance. This suggests that factors other than numbers are included in the index. These could be seasonal trappability or variation in the amount of area sampled as a result of different movement rates.

Most trappers find the catch per unit of effort less in hot weather than in cool, but they also find far less distribution of fox signs in summer. The author and others he has contacted have had little difficulty in trapping foxes in summer where their signs were present. This indicates that there is no great difference in the trappability between seasons but that in summer less fox-trap contacts are made due to the restricted movements of foxes. Sheldon (1950) and Richards and Hine (1953) also report greater fox movements during fall and winter. Consequently, summer traplines would sample narrower strips than would winter lines. The index therefore would be an expression of both numbers and degree of movements of foxes in a population. The greater movement of individuals within a population tends to increase the contact rate among its members. This possibly accounts for the peaks of rabies which occur in fox populations during the winter months.

The census involves trapping along suitable fox travelways. Observations indicate that foxes, as other animals, prefer to travel along ways that offer the least resistance; consequently, in their wanderings, they rarely cross an open trail without following it some distance. This habit gives a linear concentrating effect of the foxes and thus lends itself to a simplified sampling procedure.

To determine the areas most frequently visited by foxes and to determine if a sampling of travelways were justifiable, 59 paired stations were established in three areas. The paired stations were in series spaced at 0.2 miles. One station of the pair was located at the edge of a travelway (primitive road) and its companion was located 50 or 100 yards from the road in the adjacent field. The stations were raked so that tracks could be detected, and lure was placed on a scent post in, or at the edge, of all stations. Thirty-five paired stations were checked for three days and 24 for two days, giving a total of 306 "track nights" or 153 for each, the road and the adjacent land. Each day, the previous night's tracks were cleared, and records were kept on the presence or absence of fox signs. Thirty-three (55 per cent) of the road stations were visited by foxes a total of 46 times or a "track catch" of 30 per cent. Only 12 (20.3 per cent) of the field stations were visited a total of 13 times or a "track catch" of 8.4 per cent. These data support the observations referred to earler and give justification for use of roads as census areas.

Sampling was done in two areas to compare results obtained from trapping along improved roads (those graded and drained) and primitive roads (those with no drainage ditches and often with grassy center strips). Only those with a small amount of night vehicular travel and few or no human dwellings were considered satisfactory. The improved roads and those bordered by woven-wire fences yielded no foxes, whereas the traps along primitive roads yielded a number of foxes; hence, primitive roads are used for the census lines.

The length of the sample lines is dependent on the length of the primitive roads, most of which are rather short. Only roads at least 1.5 miles long were used.

The census was taken by placing the traps at 0.2 mile intervals and running them for one week. This time-space interval was selected after examining the results of 27 experimental lines run from 7 to 30 days and involving 5,171 trap nights. The author (1952), during studies in Texas, used trap spacings of two-tenths, one-fourth, and one-half mile intervals. He found that with foxes the closer trap intervals took an equal or higher catch and did so in a shorter period orf time.

Twenty-two lines were set with a 0.2 mile trap interval and run until there was at least a four-day lapse of time with a fox capture. Table 3 gives the results of these lines and shows that 81.8 per cent had produced all the foxes the line would produce on or before the seventh day. It shows, too, that 72.7 per cent had produced their

TABLE 3. DAYS REQUIRED TO TRAP TRAPPABLE FOXES ALONG PRIMITIVE ROADS WITH TRAPS SET AT 0.2-MILE INTERVALS

Month	Foxes caught	Days capture	Trap days after last capture	Total trap days
May	2	2	9	11
May	1	1	12	13
May	2	3	4	7
March	2	5	15	20
March	4	2	18	20
Feb.-March	1	14	6	20
November	5	8	11	19
September	0	—	21	21
November	2	12	0	12
August	3	3	5	8
June	0	—	8	8
June	0	—	8	8
June	1	1	9	10
June	3	6	4	10
June	2	2	8	10
July	2	6	9	15
June-July	3	3	17	20
July	7	9	4	13
July	3	5	3	8
October	4	6	7	14
November	3	7	3	9
October	11	7	11	18
Average of 19 producting lines	3.2	5.3	8.1	13.5

limit by the sixth day and 50 per cent by the third day. Only four lines (18.4 per cent) captured foxes after the seventh day. An average of 5.3 days was required to trap all of the trappable foxes on the 19 lines which produced foxes.

The procedure involved in setting and baiting the traps was kept constant to add to the uniformity of the samples. A No. 2 Victor coil-spring fox trap was used, and it was reset in the original site after a capture. The trap chain was wired to a drag stick so that the trapped animal would leave the trap site and leave it relatively undisturbed. Traps were set at the edge of the road clear of vehicular travel and the only bait used was a urine lure. About one teaspoonful of lure was placed approximately 10 inches behind the trap along a line which meets the road at right angles. This requires the fox to turn and walk across the trap to reach the lure. They were re-baited every three or four days or after a resetting.

The number of census lines run for an average density-contact index is controlled by several factors—the number, length, and distribution of suitable census roads; the size of the area sampled; the number of traps; and the amount of time that can be devoted. With the present knowledge of fox ranges (Scott 1943, Murie 1936, Sheldon 1950, and Richards and Hine 1953) it seems reasonable to assume that even in warm weather an area in the vicinity of one-half mile on either side of a trap line will be sampled. On this basis, a trap-line two miles long will sample more than 1,200 acres. Since it is possible to make selections which may not be typical of large areas, it is suggested that as many lines be run as suitable roads permit within the limits of available time and traps.

The density-contact index is an expression of the catch per trap mile. The index is obtained by multiplying the number of traps in a census line by 0.2 (the spacing of the traps) to give the trap miles. This figure is divided into the total fox catch for the line. The number obtained is the catch per trap mile or density-contact index.

The populations of three Florida counties and four Georgia counties have been censused (Table 4). Two counties have had no known rabies, one had the disease in dogs and cattle, and four had it among the foxes. In only one of the counties with infected foxes did the disease reach epizootic proportions and in this county, the index was higher than that of any other. These limited data suggest that a population represented by a density-contact index of 4.1 is sufficiently high to allow an epizootic whereas populations represented by indices of 1.6, 1.5, and 1.0 have a contact rate too low to support an epizootic.

TABLE 4. THE DENSITY-CONTACT INDEX OF FOXES IN COUNTIES REPORTING THE DISEASE AND IN THOSE APPARENTLY FREE OF THE DISEASE.

County	Date	Density-contact index	Status of rabies
Jefferson, Fla.	May-June	1.21	None
Thomas, Ga.	October	1.11	None
Mitchell, Ga.	July-Aug.	2.07	Dogs and cattle
Newton, Ga.	January	1.50	Fox, not epizootic
Baker, Ga.	May	1.00	Fox, not epizootic
Washington, Fla.	November	4.10	Fox, epizootic
Jackson, Fla.	February	1.66	Fox, not epizootic

SUMMARY

Sylvatic rabies was first reported in Georgia in 1939. Since then, 1,201 rabid foxes have been examined in the laboratories. There are three areas in the state where the disease has an annual recurrence rate of 50 per cent or more.

Florida recorded its first rabid fox in 1942 and since then the laboratories have examined 49 positive foxes.

During four years in Alabama, 277 rabid foxes were examined in the laboratories. Three areas of high endemicity are suggested; two of these are continuous with those of Georgia.

In addition to foxes, rabies has been reported in skunks, bobcats, raccoons, and bats; but only in Florida have any of these species been reported as important vectors.

Cooperative fox control programs have proven beneficial for immediate relief in epizootic areas. They have not, however, prevented the recurrence of the disease in the areas of high endemicity.

A technique for acquiring a density-contact index of fox populations is discussed. The method gives an index of the relative density and movements of the foxes.

The census takes advantage of the linear concentration produced by the foxes' habit of traveling roads. Along suitable roads, 81.8 per cent of the trappable foxes can be trapped in seven days with traps set at 0.2 mile intervals.

Censuses have been taken in six counties. Four have reported rabies in the foxes but only one has recorded an epizootic. In the county with an epizootic the density-contact index was 4.1. Other counties with the disease in foxes had populations represented by indices of 1.6 or less.

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DISCUSSION

MR. J. PERRY EGAN (Utah Department, Fish and Game, Salt Lake City, Utah): I am not quite clear how you arrived at an index, but I would like to have you explain it. Can you tell me whether one or more persons trapping in the area were able to arrive at approximately the same index?

MR. WOOD: I get the index figure by dividing the number of traps into the mileage. It is by coverting into trap miles by number of traps, and dividing back into my catch. So, it is really an expression of catch per trap mile. There were three other people taking indices in the same area I have, and we have all come in closely with the same thing. But, several have been averaged. Any one index might not give the same answer that another index gives. But when several are averaged in an area as large as a county, at least three who have conducted them have come out with similar results.

DISCUSSION LEADER ODOM: Was this two traps per station or one?

MR. WOOD: One.

DISCUSSION LEADER ODOM: If you have an index of four and you have five traps per mile, you would catch four foxes, is that it?

MR. WILLIAM G. SHELDON (Massachusetts Cooperative Wildlife Unit,): Mr. Wood, I wonder if you possibly explained this and I didn't catch it: In getting your indices from one year to the next in the same area, the same mileage of road you are covering, do you always trap in the same season?

MR. WOOD: If I were interested only in density, I would not compare seasonal data. But, since in this particular study I am interested in contact rate, then I cross seasons and will compare any season with another season. If it were only density I was interested in, or a relative census, then I could not compare seasons. Does that clear the point up?

MR. SHELDON: I think so. If you are getting your density figures one year in a certain county, you do it from the date that you get it when you read your trap line for those two or three days, and if you want to test that same area the next year, you are going to trap at the same time to compare from one year to the next.

MR. WOOD: If I am comparing the population fluctuation, then I would not cross seasons and would have to make my comparison the same season and under similar circumstances.

MR. LEW COWELLS (New York): I believe you said that within a week's time or so you could trap 80 per cent of the foxes within a given line of road, and you gave some other percentages for lesser periods of time; I was wondering, after you trapped the foxes whether you turned them loose again or whether they were destroyed?

MR. WOOD: I have done both. I have got areas where I am releasing and where I am removing or killing the animals. In the areas where I am killing them, they are not areas that I expect to return to in the very near future to check census. But, in the other areas where I am releasing, I am keeping those areas as permanent areas to study populations and movements.

MR. COWELLS: I still don't understand how you arrived at the conclusion that you could catch 80 per cent of the foxes along that line of road within a week.

MR. WOOD: I will modify that a little to 80 per cent of the trappable foxes. I ran the trap lines for a minimum of 21 days, and in all cases, I had at least a four-day period without a catch and in most cases had as many as eight, nine, or ten days without capture.

However, I did not catch all of the foxes until towards the end where there would be several days in which I did not catch any, and then I would catch another one, but it wouldn't be worth running the census for 20 days to pick up the one additional fox. Does that clear the point?

DISCUSSION LEADER ODOM: In other words, you are catching 80 per cent of the foxes in seven days that you could catch in 21 days.

QUESTION: Do you mean trappable foxes, foxes which visit the station? That is what you consider a trappable fox?

MR. WOOD: It is always understood there is a certain percentage of the population that are just smarter than the trapper. Those that are not I consider trappable foxes.

DR. A. STARKER LEOPOLD (University of California, Berkeley, California): In your name of rabies, I got the impression either the rabies was not known or at least poorly recorded prior to present days. But surely, the disease must always have been endemic.

MR. WOOD: It was recorded in Alabama in the latter part of the 1800's and since then it has not been recorded in wildlife until 1939 in Georgia. If it were present, it went unnoticed. It has been very noticeable since then, which indicates to me if it were present, it wasn't there in anywhere near the abundance it now is. It might have been poor reporting and poor recording, but the records go back that far and no further, to show positive fox rabies. Dog rabies have been present ever since Colonial days.

PREDATOR CONTROL IN MICHIGAN—WHEN, WHY, AND HOW

DAVID A. ARNOLD

Department of Conservation, Lansing, Michigan

For more than a century the state of Michigan has sponsored predator control efforts in one form or another. These attempts have been made for various reasons, which range from the protection of human life to the protection of wild game for human recreation. The methods of control directed against some predatory species have varied from simply a year-'round open season to the most drastic measure yet devised—poisoning. In the past three decades, however, the Conservation Department's attitude towards predators has evolved from one of wanting as few as possible of these animals to one of striving for control only when and where needed. The high recreational potential of most Michigan predators is becoming more apparent each year and the present policy is to promote these sports as much as practicable.

Throughout the country, however, the most consistent aspect of predator control in wildlife management still appears to be one of a universal lack of agreement (Latham, 1951). The agreement to disagree is as prevalent within Michigan as without. To this, the fact that the bounty system is still being used will testify. In spite of this controversy about predators, it is possible through a study of existing conditions and an evaluation of objectives to decide on a predator control program which is theoretically sound and effective in practice. Whether or not such a program can be carried out is another matter. It may be more within the realm of politics and public opinion than of practical game management.

Recently actual predator control practices have been coupled with research more often than was the case a few years ago. One important result of these research programs has been the clarification of numerous doubts expressed about some of the common predator control pratices widely used. Perhaps the most critically examined measure is the bounty system.

While northern Michigan sportsmen insist on bounties for protection of all game species, the coyote, wolf, and (formerly) bobcat, bounties are paid primarily because these predators are thought to be limiting the number of deer. All Michigan timber wolves (all six or eight remaining families) are in the Upper Peninsula. The bulk of the coyote population is also in this northern area. At present, no bounty is paid on the bobcat in Michigan much to the disgust of many residents of the Upper Peninsula. The current thinking of many of these people is a reflection of the Conservation Department's views of 30 or more years ago.

Coyotes, wolves, and bobcats admittedly all kill deer. Wolves undoubtedly can be serious enemies of the whitetail when they exist in sufficient numbers, although recent work in Canada by de Vos (1949) and Omand (1950) casts some doubt as to the ability of timber wolves to keep deer populations in check to a degree which will hold them below the limits of the winter range. Michigan's wolves are currently making a last stand, and, even though individual wolves may take a number of deer, by no stretch of the imagination can they be accused of controlling deer numbers. While coyotes are common and bobcats are not rare, the deer-killing propensity of these two species is low. The numbers of coyotes have remained fairly constant for the past nine years, a period through which the deer herd has varied with range limitations and the severity of winters.

The deer situation in the Upper Peninsula today is critical. Not because of predators, as advocates of our present bounty system claim, but principally because of the deer herd itself. At the present time, approximately one-third of the deer yards are browsed beyond their capacity to feed all the deer through the winter. This one-third of the winter range is classified as in poor condition. One-third of it is in medium condition, or just able to support the number of wintering deer, and the remainder is in good condition. However, many of the good deer yards have no deer using them and there may be some as yet unknown characteristics of the yards which make them unsuitable for deer. In Michigan there is another complicating range factor, which is also occurring in other deer states. The forest is growing beyond the productive stages for deer. This, coupled with the growing deer herd, further increases the need for action to reduce the number of wintering deer. To the ecologist, controlling predators to increase an already overabundance of deer is basically unsound. Not only will predator control do no good, but if effective reduction were accomplished, the only result could be to make a bad situation worse.

Michigan does not advocate literally throwing surplus deer to the wolves, but until our hunters are willing to harvest the surplus deer, perhaps every predator taking a deer is actually performing a service, in that some of the deer food may be saved. When the hunters are willing to harvest the deer, then perhaps employment of modern predator control methods could increase the harvest of deer in Michigan's coyote range. Recent work in the West with antelope has demonstrated that fawn production may be increased markedly through control of coyotes (Arrington and Edwards, 1951). In California, Horn (1941) reported greater deer fawn survival on certain areas after coyote reduction. We don't know very much about fawn mortality in Michigan, but we do know that under the present conditions, where our larger predators are the most numerous, increased fawn survival could not bring any added deer to our hunters. An increase in the deer would just bring added browsing pressure to the already overtaxed winter range.

Just as the coyote, wolf, and bobcat are thought by the sportsmen to be the chief enemies and controlling agents of deer in northern Michigan, the red fox is commonly accused of decimating pheasant populations in the south. This misconception was augmented by the severe pheasant decline which occurred shortly after foxes reached a population peak in Michigan. The most spectacular fox increase occurred in the main pheasant range. Here, the fox appeared to most hunters to be a newcomer, and even though foxes may well have been present in small numbers before, the animals were now numerous enough to be considered common. As might be expected, many pheasant hunters attributed their lack of success to competition from foxes. The attendant publicity given the population behavior of foxes and pheasants brought about the most costly predator control measure in Michigan history, namely the present fox bounty.

At the time of the pheasant decline it appeared doubtful that the red fox was anything more than a convenient scapegoat. However, in order to assemble information pertaining to the fox-pheasant relationship, parts of two Pittman-Robertson projects[1] devoted considerable time to such studies. Most of the work has been extensive in nature and has dealt with population studies.

The very nature of the pheasant decline in the United States was such as to throw doubt on the idea that foxes were entirely responsible. The pheasant decline was nearly universal throughout the birds' range. It occurred in many areas where there were very few foxes, and in areas where they were completely absent. In South Dakota (McEachron, 1953) it was a case of having high pheasant populations during the peak in fox numbers. Pheasants declined there in the counties where foxes were rare as well as in the counties where foxes were abundant. Ontario's Pelee Island in Lake Erie is completely foxless; yet pheasants declined there as they had in Michigan where foxes were abundant.

The population trends of these two species in Michigan were examined in considerable detail in view of the possible existence of a cause and effect relationship. The use of the best available data, analyzed by established statistical methods, failed to show that the irruption in fox numbers in 1945 was related to the low numbers of pheasants experienced in 1947 (Arnold 1952a). Pheasant numbers have recently increased greatly in Michigan in the face of a continued high fox population.

The examination of population trends was then followed up by intensive field studies on more limited areas. A survey of fox denning activity in relation to existing pheasant populations was conducted in south-central Michigan. A part of this investigation was made at the Rose Lake Wildlife Experiment Station northeast of Lansing, where intensive studies of all game species gave considerable knowledge of the available game populations. During this part of the study there were three active fox dens on the station lands. All three dens were used by a single family of foxes consisting of eight young and two adults. During the denning period a total of seven pheasants were found at these dens. Microscopic examination of fecal remains gathered at the burrows did not show any pheasant remains that could be identified, but unidentifiable feather parts were found in 10 per cent of these droppings. The pheasant population on the

[1]W89R Michigan Red Fox Investigations and W69R Michigan Predator Investigations.

station at this time was calculated to be approximately 230 birds, based on observed sex ratios and intensive crowing cock counts. It thus appeared that this fox family could have accounted for not more than 3 per cent of the spring pheasant population. Furthermore, inasmuch as the foxes were not restricted to the station area, pheasants were as numerous on adjacent lands as they were on the station, and no other fox dens were known to have been in the immediate vicinity, a much larger population of pheasants was available to these foxes than the 230 birds located on the station. When the size of the entire pheasant population available to these foxes is considered, the percentage taken by them was undoubtedly far less then the calculated 3 per cent.

Further intensive studies of foxes during the winter months are still in progress, but the findings to date show that fox predation on pheasants during the winter months is indeed negligible.

Extensive and intensive studies of the fox-pheasant relationship in Michigan have shown and continue to demonstrate that fox control measures for the purpose of increasing pheasant abundance are unwarranted. Recent investigations in New York State where fox-control was actually practiced for the express purpose of increasing pheasants bear out our conclusions on the subject (Anon., 1951).

As far as can be determined the amount of sport hunting provided by other small-game species in Michigan—cottontails, ruffed grouse, fox squirrels, and snowshoe hares—is not limited by thep redatory species towards which control measures are now directed. Recent studies by Ammann (1949) and Laycock (1952) demonstrate that hunting by man as currently practiced is not limiting ruffed grouse fall populations. After the hunting season, populations of grouse still contain a surplus above the number that will survive through the winter. Even though predation may be a principal agent in winter grouse mortality, summer predation, especially by our bountied predators, is apparently not limiting the population available to the hunters.

Predator control for the purpose of protecting domestic livestock and poultry is completely different from attempts to increase game populations. In the case of domestic stock, it is individual animals that are lost to individual predators. Control of this damage under Michigan conditions is necessary and can be accomplished practically.

Agricultural damage has been caused largely by three species of predators—the red fox, the raccoon, and the coyote. The red fox and the coyote are classed by the law as predators and bounties are paid on them, but the raccoon is legally a game animal with considerable protection. There are instances when bounty trappers have come to the aid of farmers when they suffered damage from foxes or coyotes. However, experience has shown that bounty trappers just can not be relied on for consistent help. The system is not designed to encourage the captunre of individual animals causing stock damage. In the case of the raccoon, the bounty laws are of no help whatsoever. The raccoon is classed as a game animal and furbearer and is protected for most of the year.

Michigan's present system of extension trappers, called trapper-instructors, was inaugurated in 1937. In the mid-1940's, an appropriation of general fund monies made it possible to enlarge this program to include the southern third of the state. At that time the red fox was the most serious offender in poultry damage cases. In 1946 the trapper-instructors answered 401 complaints which involved red fox damage. From the first the number of complaints involving foxes has declined each year until in the past several years, complaints of fox damage have numbered about 30 each year. An indication of the success of this method of handling fox damage is the fact that the red fox population has not declined at a comparable rate. In Missouri, another state which employs an extension trapper system, similar results in reducing the number of damage complaints caused by predatory animals is reported (Sampson, 1953).

Our chief difficulty in Michigan with this program has been a lack of promotion. Many agricultural groups are only vaguely aware of the existence of the program and many individual farmers do not realize that the service is available. As a result farm organizations are still in favor of the unreliable bounty system because they feel that it is the only form of protection. However, Missouri farmers also insist on bounties, in spite of greater promotion of the extension trapper program.

During Michigan's history of predator control, bounties have cost more money, they have been used longer, they are more popular, and they are probably less effective than any other method of control that has been used. For more than thirty years the Department of Conservation has been opposed to the use of the bounty system.

One of the major reasons that the system first fell into disfavor was the extent to which fraud became common. The years following World War I were perhaps the worst. History, which is good reading about a bad situation, tells of large-scale importations of western coyotes (Ligon, 1922; Douglass and Stebler, 1946). Traffic in coyote pelts was almost wide open at the time the legislature was finally convinced that bounties were a losing game and abolished the system in favor of a state trapper system in 1921. More recent experience with the fox bounty has demonstrated that bounty fraud has not been relegated to the past (Arnold, 1952b).

Our current studies of present bounties on coyotes, wolves, and foxes have shown other valid objections in addition to fraud, although bounty advocates are prone to make many and extravagant claims for the system. In the course of investigation a number of their claims were tested.

Even though it can easily be demonstrated that the kill of predators is often increased through bounty payments is appears that such payments have little or no effect in actual regulation of predator populations. Studies by Latham (1953) in Pennsylvania have shown that most of the persons claiming six or more foxes for bounty killed the animals expressly to collect the money. In Michigan the kill of foxes appeared to have been increased nearly 25 per cent through the payment of bounties (Switzenberg, 1952). However, in neither Pennsylvania nor Michigan has any lasting reduction in the fox population been apparent. In Michigan the coyote population has remainded nearly level for eight years without any sign of declining in spite of the high bounty ($15.00 for males; $20.00 for females) on the species. These trends demonstrate that merely increasing the kill does not necessarily have the desired effect on the population. The unavoidable but frequently overlooked fact that populations are dynamic is responsible for the maintenance of these populations.

In order to increase to kill and theoretically reduce the population, bounties are frequently advocated as subsides for low fur prices. Some Michigan trappers have even suggested scaling bounty rates to the cost-of-living. Examination of pelt prices, bounty rates, and fox population trends in a number of states during the past 11 years raises some doubt that such a scheme of adjusting bounty rates to cost-of-living and fur prices, could regulate predator numbers without prohibitive expenditures and excessive fraud.

Trends in fox populations were obtained from a number of states within the red fox range. The states were grouped in two categories. Those which used state-wide bounties in one group, and those which paid no fox bounty or had bounties limited only to a few counties in the other.

Within each group the monetary incentive for taking foxes, fur price and bounty, was compared to the population changes. The fur price was obtained from a large buying house which purchases furs in all the states. For several obvious reasons no attempt was made to compare the magnitude of fox kills within the states. Trends alone were compared. In one group, Michigan, Wisconsin, Iowa, and South

Dakota, the bounty system was used after 1945 and incentive values were then higher than in the non-bounty group where the only incentive was the prevailing fur price.

Comparison of incentive with population trends in both groups pointed out that in spite of the fact that the incentive to kill foxes increased each year for four to five years after 1940, the fox populations continued to rise. Populations were not suppressed, and it is doubtful that additional incentive in the form of the usual two to five dollar bounty would have been successful in bringing the populations under control, *i.e.*, halting the increase before what appears to have been the natural peak near 1945.

After 1945 when bounties were paid in one group of states, fur prices declined and the cost-of-living increased; thus, even with the establishment of bounties the incentive began to decline. The fox populations in these states also began to decline; however, not as fast as the incentive, nor did the population decline continue(Figure 1).

In the other group of states, Ohio, Indiana, Illinois, and New York, where state-wide bounties were not paid, populations also continued to increase as the incentive to kill foxes rose in the early 1940's. In these states, however, the populations, indicated by the kill, continued to increase for two years after the incentive reached a peak (Figure 2). Without the additional incentive provided by bounties in the first group of states, populations in this non-bounty group have appeared to decline to former levels. In the states where bounties have been paid, populations have not declined to the levels that existed prior to the irruption.

It is apparent that the payment of prevailing bounties will not reduce the population. In the period studied, 1940-1951, a population increase was not halted by an increased incentive to kill foxes. During the years that populations were increasing the incentive was increased by rising pelt prices. In the event of a similar irruption at the present time, when fox pelts are worthless, the entire burden of increasing incentive would fall on the Conservation Department. Since the population increases that occurred during the last decade were not halted by the rising incentive that occurred at that time, the bounty rates required now would be prohibitively high to even match the incentive that occurred at that time. To provide greater incentive now, the implications are obvious.

Further control of Michigan predator populations appears to be unwarranted at the present time. In view of the critical condition of winter deer food and cover in the principal coyote range, coyote control to protect deer is unnecessary. Furthermore, such control

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MEAN RED FOX KILL IN FOUR STATES* WITH BOUNTY MONETARY INCENTIVE** TO KILL FOXES

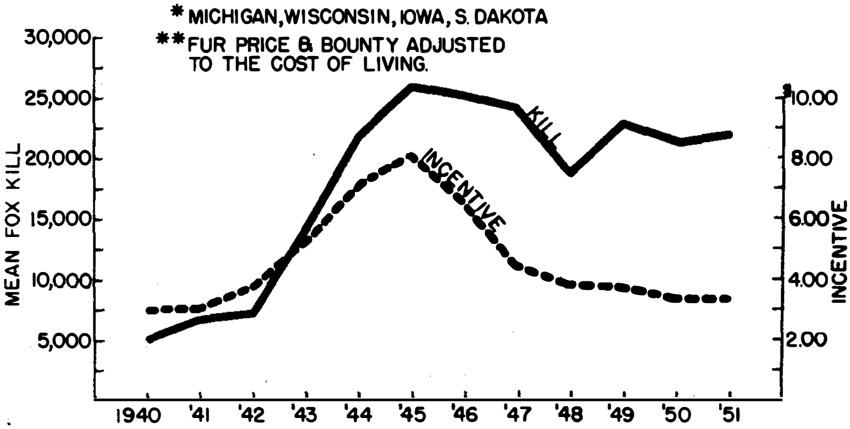

Fig. 1

MEAN RED FOX KILL IN STATES* WITHOUT BOUNTIES & MONETARY INCENTIVE** TO KILL FOXES

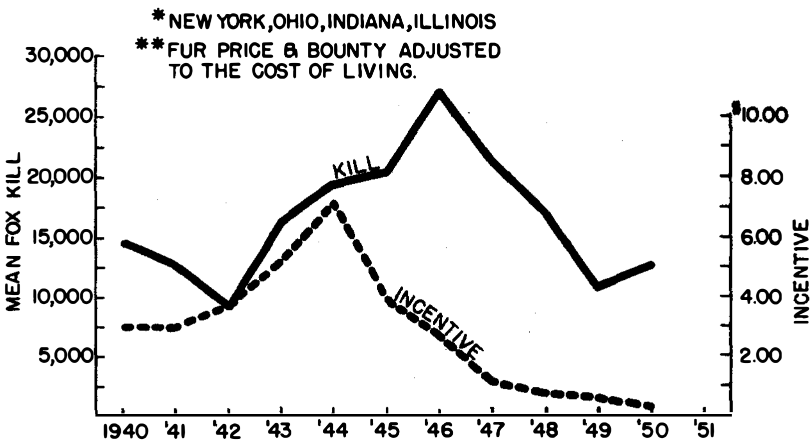

Fig 2

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GAME DIVISION

could be extremely unwise until sportsmen are willing to harvest the deer themselves and thereby preserve the range. Predators do not appear to be limiting small game crops as the populations cannot be related in either time or place. Intensive studies have shown us that pheasants are not being limited by the accused and consequently bountied fox.

The most practical and successful facet of predator control appears to be coordinated efforts to lessen livestock and poultry damage. This has proven feasible through the extension trapper system. Complaints of red fox damage have been lowered significantly while the fox population has maintained itself through the same years.

Continued study of the bounty system has shown that the incentive to kill predators does not necessarily influence the trends in the number of predators. Red fox numbers continued to increase for five years even though monetary incentive to kill them increased each year during this period. In states where the bounty system has been used to sustain this incentive, populations have apparently remained higher than in states where the bounty system is not used. To provide the incentive to kill foxes equal to that which existed during the fox irruption of the early forties would entail an expenditure of bounty funds much greater than is currently used, would undoubtedly invite fraud, and would in all likelihood not accomplish the intended purpose.

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DISCUSSION

DISCUSSION LEADER ODOM: The speaker has very closely indicated there are two distinct problems here. One is whether predator control is needed, and the other, is the bounty system of any value in predator control?

MR. ANTHONY DEVOS (Ontario Agricultural College, Guelph, Ontario): I would like to ask Mr. Arnold whether there is an increasing number of hybrids between the coyotes and dogs? In Ontario there is, and it has been our experience that it is particularly true that most people don't recognize them as such.

MR. ARNOLD: We haven't noticed any such increase. Apparently coyote-dog hybrids occur in Michigan, but we haven't noticed any increase, and I have never seen one myself. They are exceedingly rare.

MR. ROGER M. LATHAM (Pennsylvania Game Commission, Harrisburg, Pennsylvania): I would just like to make a couple of points in regards to the paper. One thing he mentioned was the fact that as long as there was an excessive deer herd and many of the animals were wasted anyway through starvation and other causes, that perhaps predation was a good thing. And another point to add to that possibly is the fact that the range deterioration caused by an excessive deer herd has a pronounced effect on small game, snowshoe hares, grouse, and cottontails, and that the predator is doing a service to the hunter in saving some of this small game. As Dave pointed out, they are helping to preserve the deer range itself.

As a matter of fact, the bounty system stimulates increased reproduction in a decreased population, so we are doing what we wish we could do in a small population. If we were harvesting game as efficiently as we are predators under the bounty system it would be a fine thing.

DISCUSSION LEADER ODOM: I take it from that, someone might dare suggest a bounty on deer? (Laughter)

Is there further discussion?

MR. PAINTER (Saskatchewan Game Commission): I would like to put that in the positive. You might say that as long as our hunters can harvest our game, we should continue our predator control. That is to say there is no use of feeding them to the predators if the sportsmen can take them. We have had a lot of experince with predators in recent years. Certainly the bounty system we can agree on. It is useless. The game hunter has proven most satisfactory in our country and we were very fortunate in that we started coyote control about four years ago, because now we have quite an epidemic of rabies in the Northwest Territory. We were in a position to keep it under control and once you inject rabies into predatory animals, you pretty well have to forget some of the other factors.

DISCUSSION LEADER ODOM: That might bring us back to the rabies, because I think it was pointed out in the case of Georgia, some people say if you don't control rabies at all you won't have any trouble. But, I believe as you pointed out, when it gets into the wild population, something needs to be done.

Would anyone like to comment on either one of those points, the reason for controlling predators or the actual bounty system?

MR. PAUL E. TRUDEL (Quebec Association of Protection, Fish and Game, Montreal, Quebec): I seemed to notice that the predators' name consisted mostly of coyotes. We haven't got them in Quebec. We have a lot of foxes and wolves. Surely there must be other predators and other methods of controlling them, because we have them.

MR. ARNOLD: We have just about all the meat-eating animals with the exception of the cougars and some of our sportsmen think we have those. We are concerned mainly with the species which in the minds of the sportsmen are going to do the damage, and therefore give us a problem by insisting that we pay bounties which we are becoming less and less able to afford. That is why we had to concentrate our efforts on those species. We have all the hawks and owls and skunks and so forth, which are predatory animals.

MR. V. W. LEHMANN (King Ranch, Kingsville, Texas): Of course, we are like these people this morning who were discussing the relative value of private and public ownership, we are pretty much on the same ground in predator control. But, I think we do ourselves damage if we make the broad statements which may seem logical on the basis of theory, but often don't work out in fact.

I was particularly interested in the suggestion about controlling some of the predators through the bounty system or otherwise, that we might stimulate greater reproduction on the part of the survivors.

In that connection, I might say that back in 1950, when we had our deer die-off in South Texas, the reproductive rate of the coyotes was lower than it had been recorded in eight years. They had all the carrion and everything they carried to feed on. But, the trappers had been counting the pregnant females for a number of years and they found a smaller number of embryos in the coyotes in the time of the greatest food abundance than at any other time.

MR. G. W. MALAHER (Manitoba): There is one aspect of this problem that has not so far been mentioned, and I would like to mention it in our experience. It was this, that one section in Manitoba where the hunting of timber wolves was found to be particularly feasible and effective, there we encouraged the people to take them. We hoped thereby to reduce the timber wolf population.

Following those most precipitant years, we found that consistently for two years, there were about 300 cubs taken. The figure did not drop below that. We began to wonder why, and a little investigation showed that those who were reaping the harvest and getting $10 per pelt decided they were not going to kill the goose that laid the golden egg—and we even dug up a female who was definitely released. Now, that is beginning to sound more like predator consolation than predator control. (Laughter)

RESPONSES IN WEIGHT AND REPRODUCTION OF RING-NECKED PHEASANTS FED FRUITS OF GRAY DOGWOOD AND MULTIFLORA ROSE[1]

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The abundant persistent fruits of gray dogwood (*Cornus racemosa* Lam.), a native shrub, common and frequently dominant in abandoned fields and farm hedgerows in New York, occurred in 85 per cent of 46 crops, gizzards, and fecal samples of ring-necked pheasants (*Phasianus colchicus* sub-spp.) collected during the winter of 1952-1953 from abandoned lands in the vicinity of Ithaca, New York (Spiegel, 1954). A similar occurrence (Handley, 1952) has been reported in northern Ohio.

The abundant persistent hips of multiflora rose (*Rosa multiflora thunbergiana* Thory), an exotic shrub extensively planted for living fences and for food and cover for wildlife in recent years, occurred in about 10 per cent of 41 pheasant crops, gizzards, and fecal samples collected during the same period from two farms with mature rose hedges in Ulysses and Caroline, New York (Spiegel, *ibid.*).

In view of the importance of the above species of plants to pheasant management in New York, an experiment designed to test the value of their fruits as winter sustenance foods for pheasants was carried out during the period February 1 through May 28, 1953, at the state Game Farm at Ithaca, New York.

METHODS

On February 1, 1953, 8 male and 32 female pheasants were selected on a trap-run basis from a large flock of uniform genetic origin hatched during the 1952 season. One male and four females, selected at random, were placed in each of eight laying pens arranged in linear fashion across an exposed holding yard. Diets were assigned to the pens as follows:

1. One pen—exclusive diet of gray dogwood fruits.
2. Two pens—exclusive diet of multiflora rose hips.
3. One pen—unlimited dogwood plus 1.5 pounds per week of stand-

[1]A contribution from Federal Aid in Wildlife Restoration Project 61-R, New York, Cornell University and the New York State Conservation Department cooperating.
[2]Formerly Research Assistant, Cornell University, Ithaca, New York.

TABLE 1. FOOD CONSUMPTION OF VARIOUS DIETS BY PHEASANTS EXPRESSED IN POUNDS CONSUMED PER BIRD PER WEEK.

	Weeks								
Diet	1	2	3	4	5	6	7	8	Totals
Controls	0.50	0.50	0.90	1.10	1.00	1.00	1.00	1.00	7.00
Intermediate rose[1]	0.10	0.10	0.40	0.60	0.60	0.60	1.00	0.80	4.20
Intermediate dogwood[1]	0.25	0.20	0.20	0.30	0.50	0.60	0.70	0.50	3.25
Rose	0.40	0.80	0.80	1.10	1.60	1.20	1.80	1.60	9.30
Dogwood	0.25	0.20	0.80	1.10	0.80	1.00	0.80	0.90	5.85

[1]Amounts listed for intermediate diets are for either rose hips or dogwood fruits. In addition these birds received 0.30 pounds per week per bird of game farm ration.

ard New York pheasant ration (whole corn, barley, wheat, and poultry pellets).

4. Two pens—unlimited rose hips plus 1.5 pounds per week of game-farm ration.
5. Two pens—five pounds per week of game-farm ration.

All pens were supplied with surplus amounts of calcareous grit, water, and green matter (fresh lawn grasses plus second-cutting mixed grass and legume hay).

Experimental foods were collected as needed, rose hips from nearby plantings and dogwood fruits from nearby abandoned fields, and were maintained at two- to three-day intervals. Levels of consumption of the various diets were recorded on a weekly basis (Table 1).

Composite samples of each experimental food from three locations each were analyzed for food components (Table 2) through the courtesy of the Cornell University School of Nutrition. In accordance with observations on the degree to which they were passed in pheasant feces, the whole fruits of multiflora rose and the pulp only of gray dogwood were used for analysis.

All birds were re-weighed on February 28 and March 28. On the latter date they were all put on diets of unlimited game farm ration.

Daily egg-production records and weekly hatching-success records were kept through April and May.

TABLE 2. CHEMICAL ANALYSIS OF FRUITS OF GRAY DOGWOOD AND MULTIFLORA ROSE

Sample Description	Moisture Per Cent	Protein Per Cent	Nitrogen-Free Extract Per Cent	Ether Extract Per Cent	Crude Fiber Per Cent	Ash Per Cent
Multiflora rose (whole fruit	5.86	7.94	51.86	7.51	24.16	4.67
Prunified gray dogwood (pulp only)[1]	3.85	5.91	35.97	46.28	4.81	3.18

[1]Pulp equals 30.64 per cent of weight of whole fruit.

TABLE 3. RESPONSES IN RELATIVE WEIGHT OF PHEASANTS FED VARIOUS DIETS

Diets	Percentage of Initial Weight After Four Weeks	Percentage of Initial Weight After Eight Weeks
Rose 1	91.26%	98.84%
Rose 2	89.71%	95.18%
Intermediate Rose 1	91.84%	96.71%
Intermediate Rose 2	90.95%	96.05%
Dogwood	91.20%	95.60%
Intermediate Dogwood	92.76%	100.01%
Control 1	94.37%	102.40%
Control 2	98.71%	106.73%

Records of changes in weight and of production and hatchability of eggs were summarized in Tables 3 and 4, respectively.

RESULTS AND DISCUSSION

All birds in the experiment remained in apparent good health and vigor during the eight-week dieting period. No differences in behavior were observed among the groups. No noticeable differences in the consumption of dietry supplements occurred. While birds on the control diet of game-farm ration maintained their weights at higher levels than birds on the test diets, there were no drastic changes in any pens. Grossly estimated, one pound of gray dogwood fruit is the dietary equivalent of about two pounds of rose hips or about one pound of a mixed-grain diet.

Although egg production and hatchability were too variable among the groups to be meaningful, the experimental diets seemed not to produce any detrimental effects.

The results of this study support the conclusions of Johnson (1951) who maintained pheasants in good condition for 27 days on an exclusive diet of multiflora rose hips.

It must be concluded that both gray dogwood and multiflora rose produce nutritious pheasant food.

TABLE 4. REPRODUCTIVE RESPONSE OF PHEASANTS TO VARIOUS DIETS

		Reproductive Responses No. of Eggs Per Hen:			
	Date of First Egg	in April	in May	TOTAL	Per Cent of Incubated Eggs Hatched[1]
Rose 1	8 April	13.00	22.50	35.50	81%
Rose 2	17 April	4.00	14.75	18.75	66%
Intermediate Rose 1	9 April	14.75	22.50	37.25	61%
Intermediate Rose 2	13 April	7.25	21.50	28.75	77%
Dogwood	12 April	7.25	18.25	25.50	76%
Intermediate Dogwood	17 April	9.25	23.50	32.75	71%
Control 1	1 April	19.00	23.25	42.25	82%
Control 2	14 April	9.00	20.50	29.50	79%

[1]All eggs hatched in commercial incubators.

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DISCUSSION

DISCUSSION LEADER ODOM: I think we will all agree that one of the trends in our modern research management is the use of experimental methods to supplement, not replace, our field work. This is a paper that deals both with the kinds of food and the amounts of food eaten.

MR. FRED H. WAGNER (Wisconsin Conservation Department, Madison, Wisconsin): About what were your temperatures during that period?

DR. SPIEGEL: It was a warm winter. There were several cold days followed by several warm, rainy days, followed by extreme cold down to five above, and that occurred three times during the experiment. However, it was a mild winter and the accessibility of food was no problem.

MR. DAILEY (Missouri Conservation Commission): Do you have any figures concerning the relative palatability of the two foods or as to the mash mixture?

DR. SPIEGEL: I didn't use the two foods in a mixture in either pan, so I have no comparison. However, in another study on a farm where there was a multiflora rose hedge, quite loaded down with fruit, the consumption of multiflora ran about 10 per cent and gray dogwood which grew sparsely on a nearby abandoned piece of land, ran about 30 per cent.

DISCUSSION LEADER ODOM: Did you determine the calorie content of these?

DR. SPIEGEL: I didn't carry the nutritional aspect of this paper further than already mentioned. I am not a nutritionist. I relied on someone else to do any analyses. It is quite possible that this sort of work can be continued with whatever food plans we are working on for various species of wildlife. I merely assumed in this case, as Dr. Odom mentioned, that the high fat content meant a high caloric content.

THE DEVELOPMENT OF NEW PEST CONTROL AGENTS

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Although we may never have thought of it, the American people are among the best fed people on earth. Each of us uses the output of at least two and one-half acres of agricultural land per year to fulfill our needs in contrast to many less fortunate peoples who per capita are thankful for the fruits of less than a single acre.

It is true that we are blessed with much fertile soil, but we are also blessed by the results of a tremendously potent force known as technology. This has provided us with better machinery for cultivating, treating, and harvesting crops and utilizing and conserving our lands, better fertilizers and methods of applying them, and better agents for controlling those organisms which threaten our food crops during the growing and storage periods.

In spite of all the progress we have made, it is generally agreed that those organisms we call pests—insects, plant disease producing fungi, bacteria and viruses, weeds and rodents—still exact a tremendous toll, up to 15 billion dollars loss each year. Two other estimates based on different criteria are that we annually lose to pests at least 10 per cent of our crops and the output of more than 25 million acres.

While at the moment we may have agricultural surpluses, in the long run with our rapid increase in population it appears that within the next half century, the current loss cannot be tolerated. This in itself justifies the search for new and better pest control agents than we now have.

The advent of synthetic organic insecticides, the dithiocarbamate fungicides, and the hormone type herbicides, 2,4-D and 2,4,5-T, during and immediately following World War II opened new vistas in the possibilities of controlling pests which have plagued mankind since the beginning of history. This progress we owe to technology, and it augurs well for future advances.

My talk today relates to the course of development of a typical new pest control agent from the time someone first thinks of it until it is introduced and finds its place in our agricultural economy. Certainly a chemist does not merely think up a new chemical compound or extract it from some natural source, try it against some insects, fungi, weeds or rodents and then, if it works, rush in to make and sell it.

Instead, in the light of our ever-increasing knowledge, the steps that must be taken before any agent can be introduced are many and complex. They involve four distinct phases and the cooperative work of men trained in a number of disciplines, namely, those of biology, of chemistry, of engineering, and of toxicology.

The first step, of course, is to find the new agent either from some natural source or from work in the laboratory. The biologist screens candidate compounds rapidly in the laboratory or greenhouse in relatively simple tests designed to pick up the slightest activity.

Once a compound has been selected as having promising activity, it is then subjected to several critical secondary screens in both the laboratory and the greenhouse from which much is learned about the quantitative biological properties, such as the minimum effective concentration, spectrum of activity, and its effect on crop plants.

We are interested in superior new pest control agents, not merely ones which are as good as and competitive with existing products. The primary purpose of the secondary screens is to indicate whether we have such a product which warrants all the necessary further work entailed.

The chemist who made or selected the candidate agent and submitted it for biological evaluation is reasonably certain of its structure, its purity and some of its important chemical and physical properties. He may have some ideas as to how safe it is to handle.

Since the secondary screens have indicated that we may have a meritorious new agent and further work is required to confirm this, more and more persons will be handling it.

Therefore, we must know, not speculate or theorize, how safe it is to handle. At this point the toxicologist enters the picture. We are fortunate in having the Haskell Laboratory for Toxicology and Industrial Medicine of the Medical Division of the du Pont Company to whom the agent can be sent for study and for determining its effect on warm-blooded test animals by various routes of administration—oral, skin absorption, inhalation and intraperitoneal. With such information the persons who must further evaluate it can be informed how to handle it safely. If the new agent passes all further tests and becomes a new agriclultural chemical, appropriate precautionary information, if necessary, may be given for the protection of man, domesticated animals, and wildlife.

The next step in determining whether the new agent really has a place in our agricultural economy is the small-plot field test. For this purpose certainly more material than can be prepared in the laboratory must be available, and the chemical engineer is called upon to provide it because of his knowledge of larger sized equipment for carrying out the reactions which are required to make the product. Likewise, few candidate materials that emerge from the secondary screens can be used as is the case in field equipment. Hence, the formulating chemist is called upon to prepare the agent in a usable form such as a wettable powder, emulsifiable solution, or even in other ways to meet current application equipment or indicated use practices.

Proper formulation is often quite difficult and involves much more than merely mixing a few ingredients together and assuming that because the formulation disperses well in water or in oil it is ready for field testing. Not infrequently the biologist on testing the formulation is discouraged to find that the activity of the new agent has been reduced. Hence, the reason for this must be ascertained and much valuable time may be spent on this phase of the development.

Once a suitable formulation or formulations are prepared, these are sent to our field investigators in the East, Midwest, West, and South for critical evaluation under use conditions. These tests are designed to pick up any weaknesses inherent in the product, such as failure to perform biologically, lack of safety to crop plants, lack of the necessary residual effectiveness, or undesirable handling properties of any kind.

Since we are interested in residual efficiency, residues on or in crop plants, or foods processed from them, and residues in soil become an important consideration which brings up the problem of accurately determining them. This is the province of the analytical chemist who is asked to devise as simple a means as possible whereby not only he but other analytical chemists can detect the presence of micro-quantities of the new agent. The analytical chemist considers all the physical and chemical characteristics of the new agent which might be useful in detecting it. It is indeed remarkable what delicate and highly accurate tests the analytical chemist can devise through research, sound reasoning, and ingenuity. Not only is a good analytical method necessary for detecting the presence or absence of the new agent, thus being a means of determining proper and safe use, but it also makes possible accurate studies on the mode of action of the new agent. It supplants speculation with provable facts and gives everyone a greater peace of mind as well as assurance when safe use is a major consideration.

Field tests over a period of several years are often required to determine the real value of a new agricultural chemical for the following reasons. Climate and weather vary from year to year. Soils, crops, and farming practices also vary widely from one geographical area to another. The ecological factors in different life zones may have an unusual and unexpected influence on the response of insects, plant disease producing organisms and weeds as well as crop plants to treatment with the new agent.

Only after our own field-plot tests show that the new pest control agent has real merit do we inform state and federal investigators about it and send them sample quantities for evaluation. The data which we have developed about its biological effectiveness, relative safety to crop plants and warm-blooded animals, and residue analyses are summarized and sent to them. The new agent is now on its own to prove its merit against the best currently available products for similar use or in new uses for which no effective material is available. In the investigator evaluations not only the desirable qualities but also the limitations of the new agent are certain to be revealed.

If it still looks highly promising or unique in the investigator tests, the chemists, biologists, and engineers carefully scrutinize all the chemical, physical, biological, and toxicological properties to be certain that no important factor which might affect its safe and effective use has been overlooked.

Its safety to warm-blooded animals by various routes of administration has been established and the amount of residues which may be expected in proper use determined through analytical methods; but one more fact still must be established, which is the maximum amount of the material that can be tolerated without injury. The toxicologist through chronic toxicity tests determines the safe amount by feeding the new agent at various levels to animals over a period from 90 days to as long as two years, depending on the nature of the intended use and the magnitude of crop residue levels.

Up to this point the new agent has never been given to anyone except qualified investigators. If everyone is agreed that the new agent really is worthwhile—superior to existing products, useful in crop production or the amelioration of pest problems, can be produced and sold at an economically sound price, and is safe to manufacture and use—then only is the new agent ready for introductory sales.

Before it can be sold, the new agent must first be registered with the Pesticide Regulation Section of the U. S. Department of Agriculture. At this time all information which has been developed on its chemical and physical properties, its effectiveness, its safety to crop plants, man, domestic animals and wildlife, residues on or in the treated crops, in the end products of a processed crop, and in soils, and the methods of analysis by which these were and can be determined, are submitted for scrutiny by the various biologists, chemists, and toxicologists of the Department of Agriculture and the Food and Drug Administration.

Great emphasis is laid, and rightfully so, on the proper and safe use of the new agent. The label and literature regarding the agent also are critically reviewed, constructive changes are often suggested, and sometimes further information on one or more of the complex facets of the development is requested. We believe that the whole chemical industry concurs with us that there is everything to gain and nothing to lose from such a vigorous and vigilant program which has at all times been reasonably and fairly administered by the responsible officials of the Department of Agriculture and the Food and Drug Administration. Even with federal registration in effect, further registration also must be made in most of the states before the product can be sold within their borders.

You are now aware that all the various steps in the development of a typical new pest control agent have required a long time, seldom less than five years, and the efforts of a host of investigators versed in the various branches of chemistry, biology, engineering, and in toxicology. The amount of money spent in such development of one product is seldom less than one million dollars. This is exclusive of the money that will be spent in providing the necessary plant and equipment for its manufacture.

Even after it is introduced on a restricted basis, any new pest control agent must be carefully and closely serviced to be sure that it is used in the right amount, in the right way, and safely to meet approved needs. It is only in this way that the potentialities of a useful product can be fully realized and its place in our agricultural economy established.

DISCUSSION

DISCUSSION LEADER ODOM: It is gratifying that the steps between the test tube development and the use of our poisons is long and that there are many checks along the way. There is one step in the process that was described which I feel is perhaps bigger than most of us realize. That is the step between the laboratory field test and its true application to nature.

I feel there are two very important things here that are coming up for discussion and that is, there is a big difference between the use of these chemicals on agricultural lands and in complex situations such as forests, marshes and so forth. In other words, agricultural lands represent what we would call a fairly simplified ecologic situation where we wish to control certain parts of it, where one is already controlled. The complex ecologic situation such as marshes and forests are entirely different things. I don't think enough attention has been paid to the step of transferring from small plots and agricultural phases to spreading these things on the more complex areas where we really don't know what is happening.

DR. DIETZ: If a pesticide is used in any way for which it is not registered, that is definitely a misuse. All the approved uses and directions for these uses appear on the label. Any other use, therefore, is not an approval use.

MR. ODOM: That is a very important point. In other words, if you have benzine hexachloride or something containing it to be used for certain insects and plants, if it were used to spray something else, you would say it was a misuse?

DR. DIETZ: I would say that what Mr. Odom is referring to is a definite misuse. This does not mean that wildlife or other qualified investigators cannot experiment with a pesticide to determine its usefulenss. If its use proves desirable, label claims and direction for such use can always be submitted to federal and state registration officials for approval. This is the way in which new uses for both existing and new pesticides are developed and become approved uses.

Mr. Odom's scond question ties in closely with his first remarks. Before marshes or any non-agricultural areas are extensively treated with any pesticide, careful consideration should be given to the possible effects on fish and wildlife. All the information on the proper and safe use should serve as a guide in avoiding trouble. Most of the complaints against or criticisms of pesticides arise because of their misuse.

MR. ODOM: Is there anyone here from the University of Michigan? Dr. Graham, would you like to comment on that? I know you are interested.

DR. GRAHAM: No; but I would like to call attention to the fact that Dr. Dietz' company is one or the few that we can commend very highly with respect to their care in evaluating an insecticide or fungicide before it is released. Some other companies are inclined not to be quite so careful, although the United States Government tries to make them be just as careful as Dr. Dietz' company.

MR. ODOM: You feel then that the controls and safeguards on the use of these chemicals are adequate at the present time?

DR. GRAHAM: That is putting me on the spot. I think we shouild always be on the alert to find unsuspected or unexpected reactions of any chemical we apply in nature, although every possible precaution has been used, there is always the off chance that something may go wrong under a particular set of circumstances, and I am certain that the insecticide manufacturers are just as anxious to find out those things as we are; and once a material has been shown to be dangerous, I am sure that the company that manufactures it will be the first to want it off the market.

MR. ODOM: I don't want to be misunderstood. I am not criticizing, of course, the duPont Company for anything. I was just simply making a point there is a fundamental difference in the way you can study or go about testing for agricultural pests and one that is concerned with the wildlife community. I know there has been some work in Ohio State.

MR. ARNOLD O. HAUGEN (Wildlife Research Unit. Auburn, Alabama): I rather suspected some of the states may have run into some of the same trouble we have in one or two cases if they have done some work with it. We do have a state Department of Toxicology, but even with their help we have been informed that they are not always able to tell whether any of these newer insecticides were involved in the death of wildlife or not, and I am wondering if Dr. Dietz can tell us whether there is any one central laboratory where specimens can be sent for definite determination that cannot be made on the local level?

DR. DIETZ: Insofar as I know, there is no central laboratory where those specimens can be sent. Our analytical chemists have frequently supplied information on analytical methods, where our products are involved, to various state, U. S. Department of Agriculture, and Food and Drug Administration chemists. Other companies do likewise.

SOME FIELD AND LABORATORY ASPECTS OF DUCK SICKNESS AT WHITEWATER LAKE, MANITOBA

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INTRODUCTION

Duck sickness has taken a large toll of birds in recent years on Whitewater Lake, a prairie marsh located near Boissevain in the southwestern corner of the Province of Manitoba, Canada. In the fall of 1949, following a summer of exceptionally heavy losses, plans were initiated for a research program in the area. Because of the broad scope of the intended study, the objectives were divided into two natural divisions: one concerned itself with the avian sickness directly, while the other had as its general purpose a study of the waterfowl populations that frequent the area. The former phase was conducted during the summer of 1950 and resulted in an unpublished report by Colls and Neufeld (1950) submitted to the Canadian Wildlife Service. The latter phase was pursued throughout the open-water months of 1950 and 1951 and at intervals during the same period in 1949 and 1952 (Bossenmaier, 1953 and 1953a).

During the course of the four-year population study, certain opportunities arose to obtain information on the sickness problem. The field observations included in this paper are those made by Bossenmaier and are based on constant familiarity with the lake acquired with the aid of an airboat and periodic aerial surveys. The laboratory aspects of the study were carried out under the direction of Olson as a result of his special interest in algal and bacterial toxins which may affect water quality (Olson, 1951). In order that the field and laboratory efforts might be fully integrated, he also visited the Whitewater area during the die-off period in August 1950 to acquaint himself with the field conditions. The laboratory work itself was done by Olson, Rueger, and Dunn at the University of Minnesota and involved the examination of algae samples and ducks collected at Whitewater Lake by Colls and Neufeld in 1950 and by Bossenmaier in 1951.

Several conservation agencies accepted the burdens of financing and equipping the field investigations. They were the Wildlife Management Institute, operating through the Delta Waterfowl Research Station; the U. S. Fish and Wildlife Service; Ducks Unlimited (Canada); the Manitoba Game and Fisheries Branch; and the Canadian Wildlife Service. The laboratory studies were sponsored by the School of Public Health Laboratory, University of Minnesota, and were supported in part by a grant from the Division of Research Grants and Fellowships, National Institute of Health, Public Health Service.

The writers are deeply grateful to K. E. Story, Kee-man for Ducks Unlimited (Canada) for field assistance, and to A. S. Hawkins, U. S. Fish and Wildlife Service, and H. A. Hochbaum, Delta Waterfowl Research Sation, for encouragement, assistance, and advice throughout the study. Numerous other individuals, all of whom merit personal mention, cooperated on frequent occasions. To them and to Lauren Dunn who aided with the bacteriological studies, the authors extend their sincerest thanks.

DESCRIPTION OF AREA

The Whitewater Lake basin is a large, flat, slightly depressed area lying at the northern base of Turtle Mountain. The relatively smooth and level plains region surrounding the basin is fertile agricultural land almost exclusively devoted to cereal grain and flax farming. The lake bed is marked around much of its periphery by a low rampart or ridge of sand, gravel, and loam, which varies in height up to 15 feet. Along its east-west axis the bed is some 12 miles long, and along its north-south axis, some 4 miles wide. The flatness of the bed is illustrated by the fact that there is only a 5½-foot rise from the lowest point to the base of the rampart, with much of this rise occurring in the outer portion.

The bed serves as a catch-basin for run-off water from the north slope of Turtle Mountain. The major increment of water added to the basin each year comes down the mountainside in the form of snow water and early spring rain water. The basin lacks an outlet, except perhaps during times of extremely high water levels. A history of water levels compiled by Bossenmaier (1953) reveals that since 1900 the lake varied from 6 to 9 feet in maximum depth for 10 years, from 4 to 6 feet for 5 years, from 2 to 4 feet for 13 years, and from 0 to 2 feet for 18 years, and was dry for the major part of 7 years. The recent history shows that the basin was dry in the early 1930's followed by a gradual return of water beginning in the latter years of the decade. By the early 1940's there were from 2 to 4 feet of water in the deepest area. Between 1948 and 1951 the maximum depth was from 4 to 6 feet. The greatest depth since the early 1900's was reached in the spring of 1950 when it was measured at 5¼ to 5½ feet. At this time the water's edge in places was commencing to climb the rampart marking the basin rim, and approximately 37 square miles of the bed were inundated. A more than 2-foot drop in the level of the lake between the spring of 1950 and the fall of 1952 resulted in tremendous acreages of the lake bed going dry.

The flatness of the lake bed and annual summertime recessions of the water's edge result in the formation of large areas of shallowly flooded land, often called feather-edge, and mud flats. In years of high water, such as 1950, when the lake's edge was climbing the basin rampart, feather-edge is much less pronounced than in years of low water. During 1950 and 1951 feather-edge and mud flats were most common in the eastern portion of the lake proper.

The slight lake bed gradient and the large expanses of open water favor the development of seiches or wind tides. A 11½-inch tide of this kind was measured on one occasion in the eastern part of the lake following several hours of a 25 to 35 m.p.h. west-northwest wind. Broad bands of mud flats and meadow with imperceptible slope bordering on the water's edge became alternately flooded and exposed as a result of these wind-caused water movements.

The flat nature of the lake bed allows the development of tremendous acreages of homogeneous aquatic-vegetation types. Following the return of water to the basin in the late 1930's and early 1940's, extensive and dense growths of emergent vegetation covered the entire submerged area. Prairie bulrush (*Scirpus paludosus*), whitetop (*Scolochloa festucacea*), broad-and narrow-leaved cattail (*Typha latifolia* and *T. angustifolia*), and hard-stem bulrush (*Scirpus acutus*) reportedly were the dominant species present. The continued rise in water levels resulted in the elimination of huge quantities of these emergents. Possibly some 17 square miles of the lake bed were transformed from a veritable jungle of emergent vegetation to relatively open water between the mid-1940's and the spring of 1950.

The major portion of the lake from 1950 to 1952 was open water interspersed with sago (*Potamogeton pectinatus*) beds and sparse growths of hard-stem bulrush. Large shallow marsh areas in the east and southwest were covered with dense emergents, predominantly whitetop. Lying between the eastern marsh area and the deeper, open-water portion of the lake proper was an intermediate zone consisting chiefly of hard-stem bulrush and broad- and narrow-leaved cattail interspersed with open water areas.

The salinity[1] of Whitewater Lake was evidenced by a comparison of its halophytic vegetation with that discussed by Rawson and Moore (1944) for the saline lakes of Saskatchewan. These authors stated:

[1]The term salinity as here used is in accordance with the views of Rawson and Moore (1944).

"The exposed shores of the saline lakes have a very characteristic flora of halophytic species . . ." Of 16 such species which they list, the following ten were common on Whitewater Lake:

Triglochin maritima L., seaside arrow-grass
Distichlis stricta (Torr.) Rydb., alkali-grass
Puccinellia Nuttalliana (Schultes) Hitchc., Nuttall's alkali-grass
Eleocharis palustris (L.) R. and S., creeping spike-rush
Scirpus paludosus A. Nels., prairie bulrush
Atriplex hastata L., halberd-leaved atriplex
Chenopodium rubrum L., red goose-foot
Salicornia rubra A. Nels., samphire
Suaeda depressa (Pursh) S. Wats., western sea blite
Halerpestes (*Ranunculus*) *Cymbalaria* (Pursh.) Greene, seaside crowfoot.

The pH of Whitewater Lake based on observations made in 1948 by McLeod *et al.* (1949) ranged from 6.80 to 8.45 between May and September. Colls and Neufeld (1950) reported readings which varied from 7.2 to 8.5 during the summer of 1950. During the latter year, incrustations of salts, said to be largely those of calcium and magnesium by Colls and Neufeld (1950), were conspicuous on drying portions of the shore and on emergent vegetation.

DUCK SICKNESS

Years of occurrence.—The record of previous occurrence of die-offs has been reconstructed as completely as possible. The only available early record was supplied by Hamilton M. Laing, a school teacher-naturalist, who spent considerable time on the lake in 1904, 1905, 1912, and 1914, and kept detailed notes on his observations. In a letter to Bossenmaier dated February 15, 1952, Mr. Laing remarked: "It was on the bed of Whitewater Lake about this same year (1912), that I first met numbers of dead and dying ducks . . . I suspect this was August 22, 1912 for on that day I visited the Island on north side."

Avian die-offs have been recorded on Whitewater Lake each summer since 1944 and also in the spring of 1950. The possibility of waterfowl die-offs having occurred before 1912 or from 1913 to 1943 should not be discounted, for it has been noted that few local residents visit the lake during the summer months, and that in 1950, 1951, and 1952 most of the sick and dying birds were found in relatively inaccessible portions of the basin.

Intensity of die-offs. There are few reliable data available concerning the seriousness of sicknesses before 1949. The headline, "Strange Disease Kills Ducks in Thousands at Whitewater," appeared in the

Deloraine Times of September 14, 1944 and indicates a major outbreak for that year. The 20,000 casualty figure placed on the 1945 die-off by Cooch (1949) suggests another major die-off for that year. The sicknesses of 1946, 1947, and 1948 are said to have been relatively light by Cooch (1949), Hawkins (1947), and Hawkins and Cooch (1948). However, the mere fact that brief surveys of short stretches of accessible shoreline revealed outbreaks in the latter three years suggests the possibility that many thousands of ducks died during each of these summers in the more inaccessible areas.

The summer of 1949 witnessed the first intensive survey of sickness losses on the lake. Frequent shoreline inspections throughout the summer and airboat surveys from August 5 to 12 prompted an estimate of between 50,000 and 60,000 for the number of birds that died (Cooch, 1949).

Thorough coverage of the lake was made by airboat and airplane during the ice-free months of 1950, 1951, and 1952. An estimated 3,000 birds perished on the lake in the spring of 1950, and 1,500 more died during the summer (Bossenmaier, 1950). It was estimated that 2,000 ducks died during each of the summers of 1951 and 1952.

The relative severity of the summer die-offs on Whitewater Lake can be appreciated when total population figures are considered. Hawkins and Cooch (1948) remarked: "By July 20 (1948), the population had built up to about 50,000 . . . ," and that, "The total number of ducks on the area in late July 1948 was not significantly different from the total at the same time in 1947." Cooch (1949) stated: "From early June to late September its duck numbers are in the hundred thousand class." Peak population figures obtained by aerial transect methods during July and August of 1950, 1951, and 1952 approached 65,000. It is readily seen that several of the sickness outbreaks on Whitewater Lake were extremely harsh as based on a comparison of total population figures with die-off estimates.

Nature of recent die-offs. During the severe die-off in the summer of 1949, sick and dead waterfowl were recovered along all shorelines and in offshore waters and vegetation beds. No areas were noticeably spared from the malady. Greater numbers of affected birds in some regions could well have been due to greater concentrations of birds in those areas. Sick birds were common to abundant from early July (Cooch, 1949) until freezeup, according to several duck hunters. Based on a sample of 6,170 affected ducks examined throughout the summer (Cooch, 1949), less than one per cent were diving ducks; the majority were dabbling ducks, chiefly mallards and pintails. The ratio of healthy diving ducks to healthy dabbling ducks on the lake was believed to approximate the above ratio. Other birds noted as dead or dying included untold numbers of shorebirds, two sandhill cranes, several marsh hawks and peregrine falcons, and numerous black-crowned night herons and American bitterns.

The spring die-off of 1950 was first detected on May 5, but based on the state of decomposition of birds recovered on that date it was apparent that the first birds became affected about the time of their arrival near April 15. In contrast to the previous summer's die-off, the duck toll in the spring sickness was 100 per cent divers, of which lesser scaups comprised 82 per cent as based on a sample of 542 birds checked at random. Fifteen coot were recorded as moribund or dead. Although dabbling ducks, gulls, grebes, shorebirds, and other birds were well represented on the lake they were rarely noted among the sick or dead.

The rate of this spring die-off, based on extensive field observations and on periodic clean-ups of affected birds along certain shores, was closely correlated with numbers of diving ducks on the lake from mid-April until shortly after the middle of May. After the latter date the die-off rate rapidly diminished independently of numbers of diving ducks present. No certain reason can be advanced for the cause of the decreased die-off rate. However, two phenomena that occurred at about the same time may have been responsible in a direct or indirect way. They were the period of heavy spring run-off from Turtle Mountain between May 9 and May 20 when the lake level rose 12 inches, and the departure of the last lake ice on May 15. Fresher water conditions, warmer water temperatures, and wind and wave action may have acted to reduce the rate of die-off.

Spring die-offs on lakes which experienced serious outbreaks the previous summer are of quite common occurrence, according to informed waterfowl biologists. Apparently on Whitewater Lake the two outbreaks described above were closely related in the matter of causative agent; the agent probably was retained under the ice over winter. It is believed noteworthy that affected diving ducks were recorded on all portions of the lake bed that were flooded the previous summer; few were noted on areas newly flooded in the spring of 1950. The higher water levels in the spring of 1950 are thought to have been responsible for removing the toxic agent from the reach of dabbling ducks as these birds primarily frequented areas of the lake that were unflooded the previous summer such as the band of new water around the entire lake and the newly flooded bays and meadow areas.

The summer die-offs of 1950, 1951, and 1952 resembled the 1949 outbreak in the dabbling duck to diving duck ratio of affected birds.

Numerous shorebirds as well as several marsh hawks and peregrine falcons also were recorded from the outbreaks of the latter years.

In contrast to the summer die-off of 1949 when dead waterfowl were found over the entire lake, the summer outbreaks of the next three years were sharply localized in those areas where wide mud flats, extensive feather-edge, and decaying organic matter were most abundant. These areas were mainly in the eastern portion of the lake proper, and in one small area in the southwest. Sick and dead birds were recovered in these areas from loafing bars and from nearby offshore vegetation beds. The remainder of the lake only rarely produced an affected duck although healthy ducks were common. Some sick shorebirds, however, were recovered on mud flats around the lake where sick waterfowl were not noted.

The pattern of summer die-offs in 1950, 1951, and 1952 was closely comparable each year. Small numbers of birds were affected almost continually after sickness was first detected with sporadic intervals of more severe die-offs usually of several days' duration. The light periods would usually produce fewer than 20 sick or freshly dead ducks every few days in all the affected areas, whereas during the peaks the daily toll was estimated in the low hundreds. During the continuous studies of 1950 and 1951, the first sick ducks were noted in early July; sick birds were an uncommon sight in late September and October.

Some correlation appeared to exist between periods of high air temperatures and peak periods of sickness. In general, the heights of summer sickness occurred a few days after each period of high temperatures. Other unmeasured factors, however, were suspected to be operating since hot days did not always produce anticipated results in the rate of the die-off.

Probable long-term factors related to die-offs. The recent history of sickness on Whitewater Lake is believed to be related to the recovery of the lake from the drought in the 1930's. The most serious die-offs were experienced between 1944 and 1949, a period during which slowly rising water levels caused a tremendous amount of emergent vegetation to be uprooted. The die-offs during the summers of 1950, 1951, and 1952 were minor, possibly because the generally higher water levels in comparison to previous summers decreased considerably the amounts of feather-edge present, and because only insignificant amounts of rotting emergent vegetation were present after 1949. If this hypothesis is correct, future die-offs will probably never equal in severity those of 1944 through 1949 unless the required conditions are repeated.

Possible mortality factors. Botulism has received most mention as the probable cause of the waterfowl die-offs on Whitewater Lake. As early as 1944 the botulism theory was advanced in the following statement which appeared in the *Deloraine Times* for September 21, 1944: "Botulism killed off from 5,000 to 10,000 ducks in the Whitewater Lake area in southern Manitoba since July, B. W. Cartwright, naturalist for Ducks Unlimited, estimated here Thursday." In the Annual Report of the Manitoba Game and Fisheries Branch for the Fiscal Year ending April 30, 1945, it is stated: "Heavy mortality in ducks at Whitewater Lake was diagnosed as Botulism, from specimen submitted to the Laboratory." Cooch (1949) remarked: "Botulism is held responsible for most of this loss, . . ." Colls and Neufeld (1950) said: "Botulism is suspected, although not definitely identified, as the sickness prevalent on Whitewater Lake during the summer months."

Recent experimental studies with living sick ducks from the Whitewater Lake outbreaks are limited to those arranged by Colls and Neufeld in 1950. All their tests terminated with inconclusive results, including the attempt to increase the recovery rate of sick ducks in the "hospital" by injections of "up to 4 c.c. of the botulinus types A, B, C antitoxin. . . ." Laboratory facilities required for determining the presence of botulinum toxin in the blood stream of sick birds were not available in the field.

Since additional information was needed, certain laboratory investigations were initiated by us in 1950. These laboratory studies were conducted on moribund ducks which were killed and frozen immediately at the lake and then kept in cold storage until examined some months later. Six birds from the spring and 9 from the summer sicknesses of 1950 and 12 from the 1951 summer outbreak were included in the study.

In the case of the first bird, only ordinary aseptic laboratory techniques were employed in dissecting and removing internal organs for culture. It was then concluded that the utmost precautions were necessary to prevent contamination from the outside portion of the duck, and therefore a more stringent procedure was developed for all subsequent specimens. The technique adopted involved the usual plucking and flaming of the breast and abdomen followed by complete draping of the prepared bird in two successive cloths soaked in 10 per cent formalin. Five to ten minutes afterward the draped bird was taken into an isolation room and opened through a rectangular hole cut in the bottom of draping cloth. The entire dissection was carried out in the isolation room under a strong ultraviolet lamp. After this procedure was adopted, no organism closely resembling ***Clostridium*** *botulinum* (van Ermengem) Holland was recovered from the liver or spleen although such spore-forming anaerobes were found in cultures of outer washings of the birds and ground sections of the intestines.

1950 series: From the first bird (#8) a mallard collected August 25 and examined by the usual procedure, a strain of an anaerobe was isolated from the liver. This organism, #319-8, may be classified as *Cl. botulinum* on a cultural and morphological basis. Biochemical comparison with Ida Bengtson's strain C, also known as American Type Culture Collection #438, shows that these strains agree very closely. Protection tests utilizing commercial botulinus antitoxin likewise demonstrate the similarity. Polyvalent antitoxin containing Types A, B, and C protected against both strains, while a commercially prepared monovalent Type C antitoxin was ineffective for the type A.T.C.C. strain #438 as well as for #319-8. To check the procedures and materials the monovalent antitoxins were tested against toxins from known type cultures. Equal amounts of the toxic cultures and antitoxin were utilized as in the preceding experiments and the mixture was allowed to stand for one hour before inoculation. It was found that Type A antitoxin protected against A toxin and that B antitoxin was effective against B toxin, but that antitoxin C did not protect against toxins produced by the known Type C #438. When monovalent A and B antitoxins were checked against #438 and #319-8, B did not protect against either toxin, but A neutralized the toxin of #319-8 in two of three experiments and once out of three trials in the case of #438. The toxins of both were heat labile. The pancreas of the same bird, mallard #8, when cultured contained a similar organism, but the biochemical characteristics of a single colony isolation did not conform exactly with those of #319-8. However, the toxin produced in single colony cultures was neutralized by heat, polyvalent botulinus antioxin, and Type A antitoxin. Type C antitoxin alone did not protect and Type B was effective in five cases out of seven. A toxin which was neutralized by heat and polyvalent antitoxin was also demonstrated in a culture of the ground intestine from this bird.

Using the refined technique, bacteriological examinations were carried out on the remaining 14 ducks in this series with the following results: The ground intestines of three ducks, on culturing, demonstrated toxins which were rendered nontoxic by treatment with heat and polyvalent botulinus antitoxin. These birds included a lesser scaup (#1) collected May 20, a pintail (#14) collected September 1, and a mallard (#15) collected September 2. In addition polyvalent antitoxin was effective against the culture from the outer washings of a gadwall (#16) collected September 2. Some of the other cultures of the livers, intestines, and outer washings showed less definite toxicity, and confirmatory tests did not conclusively demonstrate the presence of organisms belonging to the *Cl. botulinum* group. In this series of birds, the cultures from the spleens were negative. Diluted ground liver tissue from a gadwall (#16) and a mallard (#17) were directly toxic to mice. In one case botulinus polyvalent antitoxin and in the other, autoclaving 30 minutes at 15 pounds' pressure, neutralized the toxin.

1951 series: Using the refined technique, no organisms resembling *Cl. botulinum* were demonstrated in the liver or spleen cultures. However, liver tissue from a pintail (#2) collected August 2 contained a heat labile toxin which was neutralized by polyvalent botulinus antitoxin. The outer washings culture from this bird contained a similar toxic agent. The intestine and outer washings culture of two others (#6 and #7), the intestine culture of a third (#5), and the outer washings culture of a fourth (#16) contained toxins which became nonlethal after heat treatment or neutralization with polyvalent antitoxin. The specimens were a mallard collected August 8, a mallard collected August 22, a pintail collected August 8, and a mallard collected August 27.

From the intestines and outer washings of other ducks of this series, an additional number of toxic anaerobes were isolated. They appeared to belong to the genus *Clostridium,* but since the project was drawing to a close, it was not possible to carry out confirmatory identification tests. Liver tissue inoculated in 0.5 to 1 ml. amounts from 3 (#5, #6, and #15) of the other 11 ducks showed toxicity, but botulinus confirmatory tests were not conducted.

Other agents than botulinus toxin have been mentioned as the cause of the sickness on Whitewater Lake. These include grasshopper poison which was spread over the lake bed during the drought of the 1930's, starvation, leeches, fowl cholera, and algal poisoning. Colls and Neufeld (1950) conclude from their stduies that there are no apparent bases for the starvation, leech, and fowl cholera theories.

Considerable speculation has been raised concerning the possible role of blue-green algae (Cyanophyta) poisoning in the sickness outbreaks. Cooch (1949) interjected the original suggestion into the problem following the appearance of heavy blooms on the lake in the summer of 1949. Then, through the encouragement of C. S. Williams, U. S. Fish and Wildlife Service, and A. S. Hawkins, the present study was initiated in the following summer. The toxicity of blue-green algae to animal life is well documented (Olson, 1951).

Algal blooms, as defined by Olson (1938) were recorded on Whitewater Lake during the summers of 1950, 1951, and 1952. The heaviest growths were found in the northeast portion of the lake in the intermediate zone of medium-dense emergent vegetation mentioned earlier. No definite blue-green blooms were observed in other areas on the lake during the study years. The blooms were most in evidence in the less turbid and relatively shallow waters enclosed by the bulrush and cattail stands. They eventually formed thick, rotting, odoriferous scums that in some areas became highly concentrated as they drifted against dense growth of emergent vegetation or sago.

Samples of algae preserved in formaldehyde for laboratory identification were collected at irregular intervals in a variety of places between June 5 and August 24, 1950. For the period May 7 to September 1, 1951, samples were taken at approximately weekly intervals in the northeastern corner of the lake. This general area had been indicated as the major region of algal occurrence by the analyses of samples and by field observation in 1950. During August spots where algae were obvious were chosen. Table 1 lists for each month the component species in percentages of total algal volume. These collections indicate that *Aphanizomenon flos-aquae* (L.) Ralfs. and *Polycystis aeruginosa* Kutz. were the two abundant species of blue-green algae on the lake in 1950 and in 1951. Olson (1951) points out that these species are usually associated with known cases of algae poisoning.

The toxicity of several fresh and frozen samples was tested by intraperitoneal injections into mice. Two ml. of the sample collected August 17, 1950 administered shortly after being collected, killed in 18 hours. Dr. R. J. Kirk (in a letter dated November 10, 1950) reported that similar toxicity was shown for algae collected on the lake August 28. Quantities of each of the three samples collected September 1, 1951 were preserved in cold storage. When administered to mice in 1 ml. amounts on February 1, 1952, they were lethal in 45 minutes or less. When tests were repeated with portions of these frozen samples on May 29, 1953, more than a year and a half after the original collection date, there was no evidence of loss in toxicity.

Discussion

The field and laboratory aspects of the duck sickness at Whitewater Lake presented in this paper indicate that more intensive work will have to be performed before the actual causative agent is ascertained. Although several of the more impetuously advanced theories appear to be without basis, the present study merely increased the probability that both botulism and algal poisoning played a part.

The tests for botulism reported here indicated that *Cl. botulinum*

TABLE 1
SUMMARY OF WATER SAMPLE EXAMINATIONS FOR ALGAE[1]
WHITEWATER LAKE, BOISSEVAIN, MANITOBA

	1950
May 15	Lake ice free
June 5	*Polycystis aeruginosa* 90%; Chrysophyta 10%
June 12	*P. aeruginosa* 100%
June 14	*P. aeruginosa* 96%; Chrysophyta 4%
July 17	*P. aeruginosa* 100%
July 17	*Aphanizomenon flos-aquae* 55% *P. aeruginosa* 35%; Chlorophyta 10%
August 1	*A. flos-aquae* 100%
August 1	*A. flos-aquae* 85%; *P. aeruginosa* 10%; *Anabaena* spp. 5%
August 17	*P. aeruginosa* 91%; other organisms 9%
August 17	*P. aeruginosa* 100%; *Aphanizomenon flos-aquae* Trace
August 24	*P. aeruginosa* 96%; *A. flos-aquae* 4%
	1951
May 2	Lake ice free
May 7 and 16	*Dictyosphaerium pulchellum* Wood. 95%; *Ankistrodesmus spiralis* (Turn.) Lemm 5%
May 31	No bloom
June 12	*P. aeruginosa* 95%
June 23	No bloom
July 3, 6, 13, 20, 25, 26, and 31	No bloom present
August 3	No bloom
August 10	Four samples showed *Aphanizomenon flos-aquae* 95%; *P. aeruginosa* 5%
August 13	*A. flos-aquae* 98%; *P. aeruginosa* 2%
August 18	*A. flos-aquae* 90%; *P. aeruginosa* 10%
August 24	*A. flos-aquae* 82%; *P. aeruginosa* 12%; other organisms 6%
August 31	*A. flos-aquae* 75%; *P. aeruginosa* 25%
September 1	*A. flos-aquae* 95%; *P. aeruginosa* 5%
September 1	*A. flos-aquae* 72%; *P. aeruginosa* 28%
September 1	*A. flos-aquae* 73%; *P. aeruginosa* 27%

[1]In 1950, 50 ml. samples were collected. Early 1951 samples were concentrated from 1900 ml. of lake water because very light blooms occurred. In August 1951 the size was reduced to 100 ml. for algae were then abundant and concentration was unnecessary.

was present in the area both years. Cultures demonstrating heat-labile toxins which polyvalent botulinus antitoxin neutralized were obtained from five ducks in each of the two series. The studies showed certain anomalous reactions when commercial antitoxins for *Cl. botulinum* Type C were used in laboratory tests. Until this situation is clarified, identification of the specific causative agent by use of monovalent antitoxins should be carried out with caution. It is also recommended that the blood of ducks should be examined for the presence of toxin in any future outbreak.

Blooms of blue-green algae known to be toxic to many animals developed on the lake in late summer, when the sickness outbreaks were at their height, and occurred in the portion of the lake where most affected waterfowl were recorded. Certain tests with fresh samples on laboratory mice showed toxicity and further tests using frozen materials 6 months and 22 months later also revealed toxic reactions. However, it should be pointed out that no definite blooms were observed along the southwestern shore where other duck sickness occurred nor along those mud flats where only dying and dead shorebirds were noted.

It appears from these data that on Whitewater Lake either botulism or blue-green algae poisoning may have been responsible for the reported losses. These agents may have acted independently or played complementary roles in the outbreaks recorded. Our available knowledge will not permit a final decision in this matter, but it is hoped that the facts presented here may serve as a stimulus to continued and carefully controlled investigations.

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AN EXPERIMENT IN THE CONTROL OF WATERFOWL DEPREDATIONS

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This is a preliminary report on a local study of the intrusion of waterfowl on unharvested grain. This intrusion has been a source of loss to farmers on the prairie south of Lake Manitoba since the early 1920's, the threat of damage varying according to the speed of the harvest—nil in dry years, heavy in very wet seasons. The problem recently has drawn the interest of many nonfarming gunners, some being helpful in keeping the birds away, others taking advantage of the early and sometimes unlimited shooting. In 1951, gunning ethics broke down seriously, and, because of this, Mr. James E. Clark, then president of the Portage la Prairie Game and Fish Association requested a special study of the problem by the Delta Waterfowl Research Station. A plan of cooperation was established with the Manitoba Game and Fisheries Branch, and the study organized jointly with that department.[1]

In 1952 the investigation was led by J. L. Howard and myself. We mapped the study area in July, then tested control measures through August and early September, until the harvest was secure. Howard continued the study during the harvest of 1953 with the assistance of Thomas Bergerud, research assistant at the Delta Station. The study area is 20 square miles of farmland reaching five miles south of the Delta Marsh on either side of the road to the village of Delta. While most of the intensive observations were within this plot, we often went to other parts of the Portage Plains where there was the threat of damage. Cooperating throughout was Roy Gilmore, game guardian of the Manitoba Game and Fisheries Branch, who patrolled the entire span of marshland immediately south of Lake Manitoba. Most of the study area and surrounding land is under cultivation. The main crop is barley, with wheat and oats about equal in second importance, only a small amount of land being given to rye, flax,

[1]We also acknowledge the cooperation of Dr. Ralph D. Bird, Field Crop Insect Laboratory, Brandon, Manitoba; Mr. Eugene F. Bossenmaier, Delta Waterfowl Research Station; Mr. J. W. Houlden, Canadian Industries, Ltd.; Mr. G. W. Malaher and Mr. Alex Reeve of the Manitoba Game and Fisheries Branch.

peas and hay. Each section of land is cultivated except for the small farm "bluffs" of trees, but about one-fifth of each square mile is given to summer fallow without crop.

Until the late 1930's the grain was customarily "stooked" in shocks awaiting the arrival of the threshing crews. By 1950, however, all grain on the study area, and most elsewhere in the region, was cut with a "swather," left flat in rows to dry, then combined. This technique has speeded the harvest, except in wet weather when the swaths may lie in the fields for many days, sometimes weeks. Such wet, cut grain is especially vulnerable to ducks, the heavy losses arising not only from the amount eaten, but that shaken from the heads by the foraging birds. All farmers feel that the problem has become more severe in wet years since the swathing technique was established. The harvest normally begins the last of July or early August, proceeding rapidly to a close within two or three weeks. In wet years, the harvest may be delayed until late September or October, and, rarely, some fields are not combined until the following spring. There were some minor delays of the harvest due to wet weather in both years of this study, but we do not wish to apply observations of 1952 and 1953 to conclusions about truly wet years which are yet to be studied. It is hoped to continue this project long enough to include some "bad" years.

The mallard is the species most frequently feeding on the fields, with the pintail a regular but less abundant intruder. The black duck each year joins the mallard in very small numbers. A few Canada geese reach the region some years before the harvest is finished, and a few local birds range out from the Delta Marsh, but the species is not a threat to unharvested grain. The mallards roost on the south shore of Lake Manitoba or on mudflats in the marsh; at dawn and in the afternoon or evening they fly out to the fields to feed. Hochbaum followed Lake Manitoba mallards 60 miles to wet fields south of Fannystelle in 1944, and each autumn some ducks go out to fields 10, 15, or even 20 miles from the lake. But during the early season, the heaviest feeding is within three or four miles of the marsh. Barley and durum wheat are the preferred grains.

THE FARMER'S PROBLEM AND ATTITUDE

Farmers close to the marsh stand to lose heavily in wet years. There is good evidence that damage on some farms in this area has amounted to as much as 20 per cent of the total crop in years of severe waterfowl pressure. There was a tendency of farmers to overstate their losses, however, and, during the course of the study, the degree of reported loss decreased as we examined the fields for evidence of damage. One farmer, whose claims for damage had reached the newspapers the year previous, shot heavily over his field the first night of swathing in 1952, reporting heavy loss. When a careful check failed to locate any evidence, he admitted his error of statement.

In general the farmer felt his problem was not given the attention it deserved, but only a few considered that responsibility for control of birds and compensation for losses rested wholly with the government. Most wished for advice and help during periods of severe pressure. Nearly all considered that some ducks must be killed for effective frightening and that the dead birds were partial compensation for the shells and time. A few were openly disappointed when scaring devices were so efficient that there was no opportunity for killing.

The farmers were interested and cooperative. Landowners both within and outside the study area set up scaring devices on their own. During the peak of the harvest, however, all manpower was busy with the crop, and there was no time left for protective measures. Harvest crews are small, and several farmers took the crop off more than one-half square mile by themselves. Despite our efforts to work on a cooperative basis, the farmers depended more heavily on the study crew for help the second year when we received almost daily requests to set up scaring devices.

Blackbirds range the grain fields in August and September in great flocks which often contain many hundreds of individuals. We found that such flocks sometimes caused severe losses of grain, but there were no complaints against the blackbird and very little effort to keep the flocks from the fields.

Protection of ducks on harvested fields is most important to the security of the unharvested crops. When these birds are undisturbed, the waterfowl are much more easily "discouraged" from using fields they might damage. We tried to encourage the landowners to keep off their harvested fields until the neighbors' crops were in, but each man felt obliged to get on with the plowing as soon as possible. One man, who had several thousand mallards feeding on a harvested field, plowed up this stubble only to suffer the pressure of the flock which moved to his swathings nearby.

There was a widespread distrust among the farmers for non-farming gunners who came out to help protect the crop. These often walked or drove on the swaths, and seldom returned to help further after they had taken a "feed" of birds.

THE SPORTSMAN'S ATTITUDE

Sportsmen encountered with guns in the August fields were generally out for a "shoot," with help to the farmer a secondary consideration. A most serious result of this attitude was shooting on harvested fields. Instead of standing boldly in a field to scare ducks from unharvested grain, gunners regularly hid in the swaths, shooting only when the ducks came within range. We found ducks feeding undisturbed at one end of a field while hidden hunters waited at the other. In one instance, hunters made our scaring devices less conspicuous in the interest of their shooting. In some fields with gunners so hidden, we watched several flocks come, feed and depart undisturbed before the gunner finally chanced a shot at birds in range.

Some hunters came long distances to shoot, often going to harvested fields without speaking to landowners. In 1951, several visitors came from as far as North Dakota in hope of August gunning. Shot birds were consumed at home, presented to friends or stored in freezer-lockers. There is no program of checking kill or presenting birds to hospitals or other public institutions. Some men carried goose calls, and several of the semicaptive birds of the Delta Station were killed in the August of 1951.

During 1952 and 1953, gunners' activities were greatly reduced in the region and sportsmen more helpful, frequently taking exposed positions and making genuine efforts to keep birds away from the fields before they came within shot range.

PROTECTIVE TECHNIQUES EXAMINED

Patrol. Since damage can be accomplished quickly without the landowner's knowledge, daily patrol of threatened areas as suggested by Bossenmaier (1953), is of primary importance. Such patrols were carried out at dawn and in the evening in a half-ton pick-up truck. The farmer was informed as soon as birds were spotted on his field and countermeasures taken at once. Some farmers operate fields two or three miles from the house, while a few go back to the city at night, hence the daily inspection permits control before serious damage is accomplished. Our own record keeping limited the extent of our patrols, but the work of Roy Gilmore suggests that one Game Guardian might efficiently patrol 30 square miles of farmland, and that all of the threatened area south of Lake Manitoba could be covered by two or three men except, possibly, in the years of most severe pressure.

Scaring devices. A modified reprint of the U. S. Fish and Wildlife Service publication ***Prevent Duck Depredations*** was issued by the

Canadian Wildlife Service, and the scaring devices described therein were tested. We found that the most effective structure and easiest to erect was the bag swung from an angled pole. We used brightly colored vegetable mesh bags (known to the trade as "Visi-net Bag," available from local merchants at 2 for 5 cents) filled with straw and tied with binder twine to a 10 foot pole placed in the ground at an angle permitting the bag to swing free. To the top of each pole was fastened a few feet of "Spirolum Whirler," the metal stripping used by filling stations, or a square tin "flasher." These devices were set up in a field as soon as it was being used by ducks. We were unable to arrive at an efficient density figure for these, but three or four placed where the ducks were feeding usually discouraged the birds from repeating visits. Where a feeding habit of several days had been established or where the field was adjacent to a resting place, we continued to add devices until the birds came no more, and in one field of 60 acres we had 16 structures. On a 120-acre field, 14 devices, set up after ducks had fed five days, were effective.

The most difficult situations were where rain had flooded fields until there were ponds of water. Here the ducks rested between meals in the day and roosted for the night. On one such unharvested field of nearly a square mile, Howard found approximately 10,000 mallards Fifteen scaring devices kept the birds away in the daytime, but they returned after dark, and 3 evenings of shooting were required to discourage use of this field.

Our observations suggest that gunfire should be used the first night the scaring devices are set up. With gunfire the first day, the birds are much less likely to return. In wet fields or in fields at the very edge of the marsh, reported use of gunfire may be required if the harvest is delayed.

Gunfire. Just as scaring devices are more effective with gunfire, so guns are more efficient if used with these structures. One farmer was unable to keep ducks from his 120-acre field with one shotgun, but none returned after 14 scaring devices were erected.

The .22 rifle bullet fired at a flock either in the air or on the ground frightens the birds away, but we did not use this because the rifle cannot be recommended in farming communities. All our work was with the 12-gauge shotgun. Despite the general belief that some ducks must be killed, we found that we could regularly turn birds away from a field at distances up to one-half mile in calm weather with a blast from the 12-gauge. Blank shells were as effective as the "heavy-loads" generally used, perhaps more so as the "blanks" gave a louder report. Skeet or trap loads were the cheapest available and just as good as more expensive shells.

Gunfire was held to a minimum by shooting only when birds crossed the fence of a protected field, the idea being not to disturb ducks going to the free, harvested fields.

In early August we encountered a few small bands of ducks not easily frightened by guns, even at close range. Birds collected from such bands were young-of-the-year not long on the wing. Such unwary birds were not encountered in larger flocks or late in the summer.

BEHAVIOR OF THE DUCKS

The midsummer start of the harvest coincides very closely with the close of the flightless period for molting adults and the beginning of flight for many juveniles. Flights going out over the fields were noticed some days before the beginning of the harvest, but it was several days after the first cutting that passage was heavy and direct. The ducks follow regular flightlines to and from the fields, these lanes being the same year after year. Moreover, there are favorite fields to which the birds come one year after the next, while other farms, sometimes close to the marsh, are seldom visited. The Douglas farm, one mile from the marsh, almost never has ducks stopping, while the Edie fields, closeby, are annually visited from the start of harvest onward through the season. Such favored fields are the ones which every year draw the largest aggregations after the harvest is completed

CONCLUSIONS

The observations of the first two years of this study indicate that, in the vicinity of Delta, Manitoba: 1) patrol of threatened areas by a trained man helped to reduce losses of unharvested grain in outlying fields; 2) a combination of gunfire and scaring devices was effective, but that gunfire must persist for several evenings in wet fields and be repeated when the harvest is long delayed; 3) ducks need not be killed for scaring to be effective.

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DISCUSSION

DISCUSSION LEADER ODOM: I understand there are similar difficulties from waterfowl depredation in other places, particularly in California. We are particularly interested in knowing whether scaring devices are useful in other places as they proved to be here.

MR. ALLEN W. STOKES (Utah State Agricultural College, Logan, Utah): I was interested in the fact that certain fields were avoided. Did you find any correlation between soil fertility in those fields?

MR. DILLON: We made no studies on soil fertility on any of the farms in the area when we set up the study.

MR. H. ALBERT HOCHBAUM (Delta Waterfowl Research Station, Manitoba): There is apparently a difference due in part of the flight lines to and from the fields. That is, one field may be closer to the marsh but off the flight line, whereas most every used field, 3 or 4 miles from the marsh, would be the terminus of the most heavily used passage.

DR. SETH GORDON (California): Mr. Chairman, I would like to ask Mr. Dillon whether in that immediate area any effort was made to set aside special feeding grounds for waterfowl which had food comparable to that which they were destroying on the farms in the region?

MR. DILLON: No, we did not set up any feeding areas. The only areas that birds had access to feed during this study were those fields either harvested or unharvested, and we protected the birds feeding on harvested areas. In that respect, you might consider these areas of food that we endorsed, if we didn't set them up.

DR. GORDON: And what was the average size of the farm units you were trying to protect?

MR. DILLON: Well, of course, in that area every square mile is farmland and every square mile is generally divided into quarter sections and sometimes these quarter sections themselves are subdivided, but on the whole, I would say the quarter section or 160 acres would be the average size.

DR. GORDON: The only reason I am standing up here is to help clarify the understanding of the group. Our problem out in California is quite different from anything you have encountered there, first, because most of the farm units are in much larger units and secondly, because the birds come in and feed on different types of crops.

For instance, we may have in August, a large influx of birds coming in to feed on Ladino clover, which the ranchers are just getting ready for their land crop in the fall. A lot of the lambs are born there in late October and November and they are getting ready for the animals in the fall.

Secondly, that is the period when the rice is beginning to harden to the point where it becomes very vulnerable, especially in early September, and at that time we have enormous numbers of birds which come in from the North and have to be taken care of somewhere. The ranchers actually hired planes to drive the birds off their ranches, and they have to be driven somewhere, either to federal or state waterfowl units or private properties, and food must be provided for them in those places; otherwise, they immediately go out again and find their food on the farms and cause trouble.

Now, that means that we have been compelled to provide anywhere from 5,000 to as much as 8,000 acres of a single operating unit for waterfowl management purposes, part of which will be probably 50 per cent raising crops of the same kind as would be attractive to the birds elsewhere. And in one of our areas in the delta just below Sacramento, two years ago, when the birds came in early, we were feeding three-quarters of a million birds a day that were being driven out of the rice country, and they were being fed on crops we provided for them.

Then, later in the winter you have conditions in the other parts of the state, particularly the Imperial Valley, where new vegetable crops are coming through, from which the birds must be herded, and the problems we face are much more difficult, even than those you are working with.

But, your findings may help us to solve some of the situations we have in California in the Central Valley. As I indicated this morning, we have wintering with us in January, on the basis of the census, roughly six million birds. Now, that creates a series of problems and ranchers have all sorts of scaring devices, including rotating lights and everything you can conceive, but the problem is much more difficult, largely because the water areas are more concentrated. Farm units where farmers individually could help themselves are much larger than your 160-acre average farm.

I don't know whether that clears up some of the thinking that some of you might have raised when you asked if somebody were here from California. We certainly do hope you can find a way to help relieve depredations, but the whole discussion points up just one thing. With us, I dare say, as with you, you have got to find a way to give reasonable protection to those who are trying to make a living from the soil or else you will find all sorts of things done which will be to the detriment of the waterfowl habitat.

In our case we must either provide some reasonable protection against crop depredations, or more and more of the farmers and ranchers will refuse to allow any of those areas to be developed and allow any of the waterfowl to feed there or allow any of the water to be diverted for waterfowl purposes. So, we have on the other end, the same problem you are talking about, but we think it is bigger.

MR. DILLON: Yes, it certainly is. I am glad we don't have your end of it.

MR. J. J. HICKEY (University of Wisconsin): I thought the point brought up by the speaker here was, under some conditions reports of crop damage can be exaggerated and game officials can be stampeded into opening up a hunting season to prevent damage. I might call your attention to the fact that in California in 1949, it took only a half-million pintails to produce a flurry of reports that opened shooting to the general public, which in the matter of hindsight should not have been done.

MR. MONRO (Canadian Wildlife Service): There have been a number of interesting points brought up in this discussion. I would like to comment on one or two made by Mr. Dillion. I think he demonstrated quite effectively that a fair amount of manpower can control or ease the depredation problem. I think that the crux of the situation there is manpower.

The obvious point to turn then here, is to suggest that as far as scaring is concerned, as Mr. Dillion has said, that has limitations. I can illustrate that by referring to an experience in Southern Alberta two years ago when a depredation situation was expected. The Game Association of our city set up a clearing house to handle requests from sportsmen to go out and help the farmers, and we had requests from farmers to receive that aid. The response of the sportsmen was tremendous. The response from the farmers would have been entirely out of hand. There are a lot of farmers in that district, though. The reason of course is, that the farmers don't like to have tomato cans and beer bottles and so forth clutter up their grain.

That means then, one of the ways of getting at it is to improve farmer-sportsmen relations, and people in Alberta are very, very aware of that situation and they are doing a lot to work for a better association.

One other point I would like to make, too, is that Mr. Dillon referred to various illegal practices which are carried on under the guise of protecting the crops. I would like to say that our present game laws include restriction of the privilege to residents of the province concerned. They also restrict hunting on areas where crops have been harvested and water areas, and prohibit the use of such practices of hiding under the swaths.

DR. GORDON: Mr. Chairman , I would like to make one comment. I have heard that our Canadian neighbors have been successful in getting better conduct on the part of the average hunter than we seem to get down here.

Now, our boys don't seem to have any better manners apparently than yours, and what to do about disturbance of the harvesting equipment and so on, I don't know. We will have to teach folks not to dump empty beer cans in an unharvested field. It will be slow, I suppose.

We also have had the difficulty of getting hunters to cooperate in driving birds away from crops because they want to go out in their own way to hide and to kill as many birds as possible, without accomplishing the thing they are really out there for. So, we have the same problem you do. But, where we do have depredation there, with the hunters being on the ground, they help to keep the birds moving. The farmers in many instances are really suffering the annoyance of misconduct on the part of a few because of the benefit they derive.

MR. LESLIE L. GLASGOW (Louisiana State University School of Forestry, Baton Rouge, Louisiana): I would like to know if crop insurance is available to farmers in that area which would cover wildlife damage?

MR. DILLON: To my knowledge no crop insurance is available to the farmers in this region.

MR. GLASGOW: Do you think they would be receptive to such insurance?

MR. DILLON: I really can't say. I don't know whether such a program has been put before the farmers or not. As I understand it, elsewhere such a program has not been very effective; too few farmers would apply and the premiums would be excessively high.

MR. J. J. HICKEY: I sat in a meeting of the waterfowl staff of the Wildlife Service in this area. The point was brought out that crop insurance is high in Canada and the farmer is naturally a gambler. e has to be, to be in that business. So, he is going to gamble with his crop in terms of the weather effects and the yields and he is going to gamble with the ducks affecting his yield also.

MR. FLICK DAVIS (U. S. Fish and Wildlife Service, Minneapolis, Minnesota): We have depredation claims in Region 3, usually on swathed grains, similar to what the people in the provinces experience. We feel that the agricultural interests have something at stake in this thing as well as the sportsman or the various conservation interests. We feel that probably no one particular thing will solve the depredation problem. We do feel a series of things such as development of a strain of wheat that can be straight combined, rather than swathed, where you lay the grain on the ground and actually set the table for the waterfowl to come in and help themselves, would help. We feel, too, possibly the use of defolients will make a contribution and probably the crop drying techniques and methods.

We are fortunate in our part of the country at least, in having the North Dakota Agricultural Experiment Station working along those lines, and we expect that over a period of a few years we will probably make some progress towards controlling depredations by the development of a strain of grain that can be straight combined rather than laying it down on the ground.

Actually, the farmers are interested in that type of operation because it cuts down their operating cost, and instead of having to handle the grain twice to get their crop, they only have to handle it once, so we are on that line and think we have good prospects.

MR. MONRO: May I make one more comment? Mr. Gordon stated the problem of California was considerably more acute by virtue of the greater concentration of birds in his area and I agree with what he said.

I would like to say though, you should by no means belittle the depredation situation on the Canadian prairies for this particular reason that the Canadian farmer controls the land on which the great bulk of the North American sporting ducks are produced, and unless we do something, our task of raising ducks becomes that much more difficult, and that would be a very critical point in the event that the ducks population goes down again.

This point has been made before, but I think it is a good point to make again.

MR. HOCHBAUM: I would like to make two more points. One was the excellent response of the farmers, the landowners, who certainly did a great deal to change the local attitude of the farmers during this crusade, from a feeling they were under pressure, that it was something that could be controlled, to a problem that could be taken care of. On the other side of it, we had a very small, but enthusiastic response from sportsmen who volunteered their help and time to come out and not to shoot or for anything else, but to stand in the fields where they could be seen and scare the birds. I think a great deal of misunderstanding has been prevalent in our region on the subject of control. Keeping the birds from the fields has been the hunter's interest in bringing birds to him rather than scaring them away. That certainly has been cleared up and corrected in this region where sportsmen are showing interest as a result of this study which was suggested.

This is only a report of two years of a long-term project in one area. Before we started, it was said to us that these techniques couldn't be applied, that it wouldn't work. All we can say is that in a small region near Lake Manitoba, three men have been able to keep the threat of waterfowl damage down.

TECHNICAL SESSIONS

Monday Afternoon—March 8

Chairman: LLOYD L. SMITH, JR.
Associate Professor, Institute of Agriculture, University of Minnesota, St. Paul, Minnesota

Discussion Leader: ALEXANDER J. CALHOUN
Chief, Inland Fisheries, Department of Fish and Game, Sacramento, California

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WETLANDS AND INLAND WATER RESOURCES

MEASURING LIVING SPACE FOR WATERFOWL

C. GORDON FREDINE
U. S. Fish and Wildlife Service, Washington, D. C.

Preserving a place in the sun for ducks and geese is the final objective of all of us responsible for managing waterfowl resources. This being the case, it is unfortunate that no nation-wide summary has been made of how much living space is available for waterfowl, or how much is needed. We seem satisfied with such answers as "We need all we have," or "The more the better." Furthermore, a tabulation of areas now set aside solely for waterfowl by federal, state, and private agencies obviously would represent only a token measurement of all the habitat needed by ducks and geese. Likewise, there has been no nation-wide attempt to correlate waterfowl population numbers with the most important segment of waterfowl habitat—the wetlands of the continent. The lack of factual information in these fields is a severe handicap in appraising the relative importance of the many forces that are reducing the amount of available waterfowl habitat in this country.

In recent years great concern over past and current losses of wetlands habitat has been expressed by conservation groups having a sincere interest in the welfare of waterfowl resources. They have seen man's activities through the years exerting a decided effect on the amount of wetland habitat available for waterfowl and other wildlife. The principal factors usually brought forth as responsible for the greatest decrease in wetlands habitat are drainage and flood control carried out in the interest of increasing agricultural production and protecting lives and property. Reclamation by filling or drainage for the development of industrial and residential sites has increased in recent decades. Drainage of swamps and marshes for mosquito control, particularly along the eastern seaboard, is another important factor. Wars and high prices have encouraged the substitution of corn for cattails. Altogether, competition for the use of wetlands is steadily growing, which points to the fact that corrective action must be taken if the required portion of the remaining acreage is to be dedicated to living space for waterfowl. Problems of diminishing wetlands extend from coast to coast and from the breeding grounds in the north to the wintering grounds in the south.

The point has now been reached where a re-appraisal of national and state wetland-use policies is needed (Fredine, 1952). National policies, through public works and public assistance to landowners, now seem to favor the reclamation of natural wetlands for purposes other than waterfowl habitat preservation. These policies are frequently not in harmony with national obligations for the conservation of migratory waterfowl. In the meantime, demands for the recreational enjoyment of the waterfowl resources continue to grow. Progress toward reducing this conflict is painfully slow from the viewpoint of waterfowl interests.

Notwithstanding the importance of properly regulating the harvest of waterfowl within allowable limits, habitat in all its phases is the key to waterfowl abundance. Therefore, in order to do a good job in the management of waterfowl resources, we must take stock of the quantity and quality of available land and water areas that make up this habitat. An inventory of this kind is now being conducted throughout the United States by the Fish and Wildlife Service in cooperation with the individual states.

The idea of undertaking a national wetlands inventory developed from a belief that realistic policies and practical action programs for conserving and managing migratory waterfowl are impossible without it. After an exploratory start, the inventory got off as a special large-scale operation on July 1, 1953. At that time, funds were provided to complete a well-rounded inventory by June 30, 1954. The inventory has become one of the principal activities of the Office of River Basin Studies during the current fiscal year.

The primary goals are to determine the location, amount, and relative value to waterfowl of the important ecological types of wetlands remaining in the United States. It is primarily concerned with marsh, swamp, overflow and shallow water areas. It is no secret that the immediate goal of the inventory is to provide information essential to an action program that would counteract present and future drainage programs. The urgency of completing a useful inventory in a short time dictated that a quick method be devised, but in cases where shortcuts had to be taken, we have tried to exclude non-essential coverage rather than sacrifice its quality.

It was recognized at the outset that we needed to know specifically what types of wetlands we were measuring. A nation-wide standardization of ecological types was needed for this purpose. This was done by a Wetlands Classification Committee appointed for the purpose from among Fish and Wildlife Service personnel particularly qualified by exeperience. An early draft of the classification was distributed to Federal and State biologists for comments and suggestions. The material was revised somewhat and published by the Service (Martin *et al.* 1953). Since this report is available and many waterfowl biologists already are familiar with the 20 wetland types it describes, the classification system need not be discussed here.

It was first necessary to establish minimum requirements for completing the inventory within the established time limit. Bearing in mind the primary purpose of making the inventory valuable to a program for preserving wetland habitat, permanent lakes and streams and similar water bodies which are reasonably free from drainage or other reclamation activities were eliminated from immediate consideration. Thus, the inventory is concentrating on those wetland areas which are more apt to be lost by these activities. The present inventory will therefore fall short of being a complete waterfowl habitat inventory, inasmuch as permanent water areas that provide habitat will not be covered.

It is manifestly impossible to cover every wetland area within the country, so two additional limitations also were allowed: (a) the elimination of wetland areas under 40 acres in size when their inclusion was impractical; (b) elimination of coverage within a state of selected broad areas that contain some wetlands but which collectively amount to no more than 10 per cent of the total important waterfowl wetlands. In other words, the coverage will include about 90 per cent of all wetlands of particular significance to waterfowl. Still another way of stating this limitation is that the wetlands covered provide at least 90 per cent of the waterfowl use occurring on wetlands within any given state.

All delineated wetlands are identified as to type and evaluated in terms of their relative importance to waterfowl. Four value categories of high, moderate, low, and negligible were established. Since no reliable criteria are available to permit direct comparison of waterfowl values from one part of the country to another, these evaluations reflect the importance of the areas to waterfowl on an individual basis. In other words, the waterfowl wetlands in a given state are judged on the basis of their importance locally. For example, wetlands given a rating of high value in Kansas would not necessarily by used by as many ducks or geese as would areas of comparable size in Minnesota assigned to the same value category. Inasmuch as the primary purpose is to gather information useful in preserving wetlands habitat rather than to make inter-state comparisons of waterfowl use, this system of evaluation is necessary. The opinions and information furnished by state and federal waterfowl biologists are relied on heavily in making these evaluations.

While the primary emphasis of evaluation procedures is on waterfowl values, the importance of the areas covered to other wildlife is not neglected. Information on wetlands-use by fur animals, big game, and upland game also is gathered from state and local sources. When available, Land Capability Class information as used by the Soil Conservation Service is obtained.

Inventory methods followed by the regional offices vary in accordance with local problems encountered. In the Lake States, for example, the great number of wetland areas precludes an individual area inventory. There a sampling technique prepared on the basis of transects was developed, tested, and found to be reasonably accurate. These transects were established to cover a representative sample of major soil groups in such manner that the data could be broken down by counties. On the other hand, states in the Southeast were covered by locating all wetlands on recent aerial photographs. Vegetative types identified on these photographs effectively permitted a basic delineation; then field checks on representative samples provided the needed information on specific ecologic types and their relative value to waterfowl and other wildlife. In states like Kansas and Idaho it was possible to locate and inspect all significant wetland areas individually. Thus, it is apparent that shortcuts are taken in some instances in order to cope with local conditions, but in all cases the methods were selected to provide dependable results within the prescribed limitations.

Results of the inventory are presented in three ways. First, state base maps (scale 8 miles to one inch) are prepared to show the wetlands in four colors indicating their relative value to waterfowl. These maps generally show only the larger individual wetlands since it is impractical to show areas smaller than one square mile in size. Individual county maps (scale 1 or 2 miles to one inch) permit the delineation of wetland areas in greater detail, and generally show areas 40 acres or more in size.

Second, for each county covered there is a table showing by wetland types the acreage and waterfowl value of wetlands in that county. Other information, such as the Land Capability Class in which the type commonly occurs as well as general information on the dominant species of plants and the use of the type by other wildlife also is given on the county sheet. Means of recording specific information on individual areas also in provided for.

The third way of presentation is by a narrative report covering the status of wetlands in each state. This narrative report describes the methods used and the special problems encountered, and reviews the evaluation procedures for waterfowl and other wildlife, and gives a general analysis of the results.

Progress of the inventory to date is keeping up with expectations even though new problems arise from time to time. On March 1, 1954, the total job was an estimated 70 per cent complete, even though only 10 completed state reports had been prepared at that time. Work is scheduled to fit in most advantageously with other activities of the Office of River Basin Studies, with the inventories for several states proceeding concurrently in each region. Barring unforeseen difficulties, field work and state reports will be completed by the regional offices by June 30, 1954. Following that date considerable work will remain in analyzing the results and preparing a national summary. In the meantime, individual state reports are made available to the state game and fish departments and other cooperating agencies about as rapidly as they are completed.

While we believe the present inventory will be very useful to all concerned, it is clear that certain additions could make it vastly more useful. Extending the inventory north and south of our national boundaries obviously would be desirable, and opportunities for obtaining the required cooperation should be explored. The additional coverage of permanent water areas would transform it into a total waterfowl habitat inventory and evaluation. The addition of the less important areas bypassed in the present coverage also would be highly desirable. While no specific plans have yet been approved for continuing this work by the Service, it is hoped that all concerned will find the basic results obtained so far useful enough to warrant cooperative efforts to do a complete job. The individual states may find the information of value to general wildlife management programs and independently carry the work forward. The inventory so far has been concerned almost exclusively with waterfowl and other wildlife aspects, but opportunities for including fishery values of wetlands should not be overlooked.

The inventory itself, no matter how complete its coverage, is only a start toward developing a wetland preservation and management program. As indicated by Cottam (1953), this inventory of wetlands habitat will be largely pointless unless we are succesful in follow-up steps to establish national and state policies insuring retention of indispensable waterfowl areas. The Fish and Wildlife Service is now considering plans for an action program in cooperation with the states to accomplish these ends. Its success will depend upon the sincerity and energy evinced by those who have a stake in future waterfowl hunting.

In establishing a follow-up program, it seems necessary first to set up some realistic goals. Chief among these is a determination of how much habitat is needed to perpetuate waterfowl in the face of increasing hunting demands. This may lead to a determination of how many ducks and geese we can expect to support in the several flyways. In making such determinations, it is probable that recent advances in techniques of measuring waterfowl populations need to be carried even farther so that production habitat, intermediate flyway habitat, and wintering habitat needs can be evaluated more precisely. It is likely that the delineations of habitat accomplished by this inventory will assist in advancing this program. The inventory data also should assist the Flyway Councils in making basic plans and help in recognizing the different limiting factors and problems that occur in each flyway.

In addition to determining how much habitat is required, we cannot escape facing the problem of how these needs may be met in the face of competing interests. We should take advantage of every reasonable opportunity for creating and managing new habitat through reservoir and other water-control projects. Wetlands restoration projects specifically for wildlife should be encouraged, while projects that would destroy wetlands of value should be discouraged or modified to prevent or replace losses. Increasing the carrying capacity of existing waterfowl management areas also is a feature that should receive increasing attention.

Acquisition by federal, state, and private agencies doubtless will be the only sure method of preserving many essential areas. Even though we optimistically depend on a substantially increased acquisition program and on advancements in techniques of managing wetlands specifically dedicated to waterfowl production, we probably must continue to depend in the future largely upon wetlands in private ownership. An answer to how we can meet this problem is obviously an important goal.

The agricultural use of land in private ownership probably has more far-reaching influence on existing and potential waterfowl wetlands than any factor subject to the control of man. Here is a good example of a trend in land-use favorable to our interests. Kimball (1953) cited agricultural authorities who believe that a changeover from a grain to a grassland economy in the rolling country of the Prairie Pothole Region will be best for the land and the farmer alike. He points out that under this kind of an agricultural program, waterfowl will be far better off than under existing land-use practices. Concepts of this kind are not necessarily limited to the pothole region; hence we may profit by keeping abreast of progress and encouraging trends in agricultural land-use programs that favor retention and improvement of wildlife habitat.

Measuring living space for waterfowl is a job that can and will be done this year. Providing and protecting this living space, and maintaining the necessary housekeeping facilities, is a far greater and never-ending job. A sound and positive program based on solid facts is the best insurance that this bigger job will succeed. We must depend on what we as wildlife specialists and administrators can *do*. We cannot afford to depend on what some other interest should *not* do. Little can be accomplished, however, unless we who are responsible for the future of the waterfowl resources can justify and obtain public support for a future that includes waterfowl hunting for Americans.

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DISCUSSION

DISCUSSION LEADER CALHOUN: To get the discussion started: How do you get around the difficult problem you must face, resulting from a variation from year to year in flood conditions and rainfall? Obviously, you can't do this too often, because of the magnitude of the job.

MR. FREDINE: That certainly is a big job, but in studying overflow lands, for example, where that problem would be the greatest, we do a job similar to the way the Corps of Engineers does. We determine what the average flood is—say, a five-year or ten-year flood—a realistic figure, and call the area "overflow lands."

Another situation is in the pothole country. We have information based on flights made over the pothole states in dry years and in wet years. In the spring, of course, many more areas are wet than later on in the fall. We take all those factors into consideration, and our estimates of wetlands are based on as many facts as we can gather of that kind.

MR. CHESTER WILSON (Commissioner of Conservation, St. Paul, Minn.): Mr. Chairman, we are familiar with the work, because we're right in the middle of some of the most important wetland territory, and up against some of the most acute drainage problems.

As Mr. Fredine knows, the men in our state department field research crews, in cooperation with the U. S. Fish and Wildlife Service, have come up with a rough answer that if we are going to get anywhere fast enough in coping with this problem of the wetlands that are being rapidly drained, we're going to have to acquire about a couple hundred thousand acres of what is now privately owned wetlands within the next few years.

I'd like to ask Mr. Fredine if that fear is consistent with the findings to his unit, and if he has any idea of about what that is going to cost, and where we will get the money.

MR. FREDINE: Mr. Wilson, to the extent that you said a couple of hundred thousand acres, I'll say yes, that is consistent with what we know of the amounts of wetlands. I want to raise this question, though. Is it feasible to put into public ownership a total area of that kind in any state? Aren't you going to run into local opposition to an acquisition program that big? I hope you don't, and I hope that states—Minnesota, in particular—can acquire every acre they can possibly afford, but the best we can do in that connection probably wouldn't be enough.

I think the outstanding problem is still going to be how we are going to get the management of the remaining privately owned wetlands, even though you buy every acre you can.

I think the Soil Conservation Service is an agency that can help us tremendously, and I think they are going to help us. In fact, one of the purposes of our inventory, right in the beginning, was to provide information that the S.C.S. could pick up and examine, to see where our problem areas were, so they could work with us in coordinating our program, so as to eliminate as much conflict as possible.

MR. WILSON: Well, I'd just like to make one further comment on the point you made—in the way of a question. How else are you going to apply effective control without the acquisition of title to these wetlands by either the State or the Federal Government, if necessary, or at least by the acquisition of an easement which will permit public protection and control of these areas, not only for purposes of nesting, resting and feeding places for the waterfowl, but for public hunting? If you don't have public control of it, you'll not solve the problem.

How are you going to stop the drainage? You certainly are not going to get very far, according to our experience in coping with this drainage problem, unless you can come to some kind of agreement with the farmer whereby he is going to be compensated, and if you are going to pay him for anything, you must get a commensurate degree of public control, or else you have no right to spend public money for the purpose.

On the possibility of getting farmers to convert to grassland agriculture as a solution to this problem, it is our definite conclusion that you wouldn't get far enough fast enough with that method.

In Minnesota today we do not have half enough grassland in our crop rotations right now, and the economic forces that grip the farmers are obstructing that very desirable process of getting more grassland. By that I mean all types of sod crops. It is very difficult to get farmers to make that change-over rapidly. Even if you get them to do that, you do not have adequate control of the water areas, because some of them will say to you that the drainage of these potholes is a very desirable thing from the standpoint of improving their grassland agriculture. They say they can put the drained land in grassland rotations.

So I think it is a vain hope that we are going to be able to cope with this problem in time, and I was wondering if—in the course of your inventory—you have got some figures on the rate of depletion that is going on, or how much time we have to get enough of these wetlands under some kind of control before they are too far gone? Because we know that once they are drained, they are lost.

MR. FREDINE: Please don't misunderstand me, Mr. Wilson. I agree with you fully that is the only way to preserve the backbone of our wetlands—through acquisition and public control—but I don't want to underestimate the opportunity, either, for managing wetlands in private control.

I think you said something very significant, and that is that we must find some means of compensating the farmer if he is going to do that on his own lands, in addition to buying his land from him. I think there are opportunities there as yet unexplored.

Another thing you mentioned is that by pushing and encouraging and helping to develop agricultural land use programs, programs that recognize this problem, where we can fit wildlife management in with good land use, we can make some gains there. I think we will have to do it, in addition to having the best public control system we can devise.

Your other question was whether or not we have information on the rate of drainage. We are gathering that, but this I think is a significant milepost in such a program. We have to start somewhere. We are getting an inventory that at least gives us a fairly reasonable picture of what we have. From this point forward it is a matter of a maintenance job on the inventory to measure the rate of decline. We have some fairly reliable estimates of what has occurred in the past, too, but from this point on we can do a more precise job.

MR. WILSON: I'd like to throw out one more point on the matter you mentioned of the opposition you run into. A large part of the opposition is due to the removal of lands acquired by the State or the Federal Government from the local tax base. We have taken quite a step toward solving that problem in Minnesota by providing for payment in lieu of taxes out of our Game and Fish Fund for areas that are acquired for wildlife purposes.

WATERFOWL MIGRATION STUDIES AND THEIR APPLICATION TO MANAGEMENT IN COLORADO[1]

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Information derived from waterfowl migration studies is a great value to state and federal agencies in arriving at the best dates for hunting seasons. The composite of such information is used for setting over-all seasons, by flyways, while the various states make use of their own data for choosing seasons within the opening and closing limitations specified by the U. S. Fish and Wildlife Service. This degree of flexibility is widely recognized as an improvement over the more arbitrary system formerly employed.

Use of migration data, however, does not end with season setting for states fortunate enough to possess extensive information on migratory birds. Such information, covering a series of years, is usually sufficient to convince sportsmen that seasons elected by the Department coincide with maximum waterfowl numbers present during limitation dates. Furthermore, such information serves practical management by permitting the Department to plan and execute seasons with relative certainty; and it serves conservation interests (admittedly mostly in the future) by disclosing species in the least, and greatest, need of protection, which may be attained by the judicious selection of open dates. Colorado, during the past few years, has derived these extra benefits from waterfowl migration studies.

Aerial migration studies have been carried on by this state since the winter of 1947-48, methods and results for the first two years having been previously reported by Kinghorn (1949). It is proposed now to: (1) evaluate the results for six years; (2) correlate aerial data with species movement as determined by ground migration counts; (3) correlate kill by species with species migration, and investigate the potentialities of regulating harvest by species; and (4) discuss how Colorado makes use of this information in selecting seasons in such manner as to give a fair share of hunting to all sportsmen in the State.

STUDY AREAS

The eastern slope of Colorado is the main migration and wintering area for waterfowl in this state because it is flat, and offers no topographic barriers to migratory bird flight. Also, it is much lower in elevation, and waters do not freeze early as they do in the mountains.

[1]Colorado Federal Aid Project W-37-R.

This eastern area has been divided into three parts: (1) the South Platte Valley, including the north-central and northeast portion of the state; (2) the Arkansas Valley, comprising the southeast part of the state; and (3) the San Luis Valley, a high, mountain-rimmed basin in south-central Colorado (Figure 1).

Aerial counts in these areas were made on main rivers and large irrigation reservoirs or lakes, which are associated with the irrigation system in each valley. This combination of types, in conjunction with related agriculture lands, offers excellent waterfowl habitat for migration stops and wintering grounds. Actually, the large reservoirs act as a sanctuary for ducks and geese during the hunting season, where they stay from morning until dark, and then feed on the surrounding croplands at night. It is only during periods of stormy weather, or after the season, that birds move into riverbottoms for shelter from the elements. Considering all areas, more than 460 miles of river, and 40 large reservoirs and lakes are counted each month (October through March), making this one of the most comprehensive aerial migration and wintering waterfowl surveys in the Central Flyway.

In addition to the aerial study, ground counts were conducted on

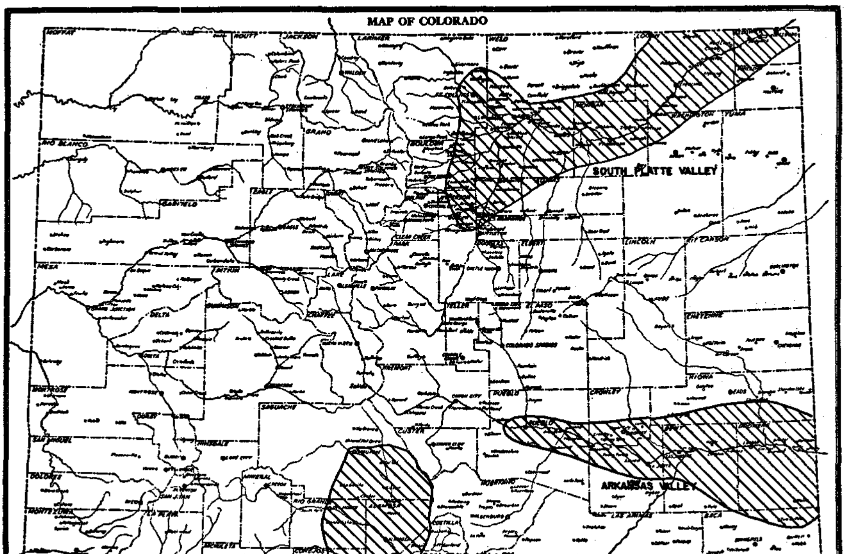

Figure 1. Location of Waterfowl Migration Study Areas in Colorado.

five large reservoirs in the Cache la Poudre Valley, north-central Colorado, for the purpose of determining migration by species. This study was initiated in the fall of 1950, and continued on a weekly basis to the spring of 1953.

METHODS

Methods of the aerial study have remained essentially the same as those reported by Kinghorn (1949). The main differences are those growing out of changing personnel and planes: the crews were not always the same, and a Cessna 170 was used in addition to the Cessna 120 and 140, as previously reported. These changes apparently have not affected the study to any great degree. Considering the magnitude of area under consideration, and the number of ducks and geese counted each month, it is believed that changes in trained personnel and aircraft do not materially alter the results.

In brief review, the river areas are flown at altitudes varying from 50 to 200 feet, at an indicated air speed of approximately 75 miles per hour. The flight path varies according to the course of the river. In many places, circling is required to put the observer in position to observe divergent and multiple channels or ox-bow lakes. Depending upon the density of concentrations, the observer usually records numbers on tally counters by tens or hundreds. All geese observed are called to the pilot who records them on a tally counter attached to the throttle quadrant.

Lakes and reservoirs are counted by circling the perimeter, and then stripping the open water. When frozen, with ducks concentrated around one or two small holes, a grid system of estimating is used. This process consists of dividing the raft into units, counting the birds in one or more units, and computing the total number in the raft in this manner. When a sizable number of geese are encountered in a dense raft of ducks, it is sometimes necessary to flush the raft and count the geese in flight.

Waterfowl counts by ground methods require the use of a 20-power spotting scope. When numbers on each lake are less than two or three thousand, the birds are counted individually by species. However, when numbers are large or the ducks are in a raft, it is necessary to estimate totals by species. This is done, first, by scanning the lake and listing all species present; second, several scope-fields of average raft density are counted by species, and then by swinging the scope, the total number of scope-fields in the raft are determined. The average number of each species counted in the sample, times the total number of scope-fields in the raft, gives an estimate, by species, of the total number of ducks present.

RESULTS

Ducks. The graphed results of the six-year aerial study reveal a definite conformity in movement by ducks between years (Figure 2). On the average, there is a steady influx of ducks into Colorado, beginning in September, with large flights usually noted in late October. Peak populations normally occur in December, and duck numbers taper off after this time until late February or early March, when the thaw occurs and the first spring movement begins.

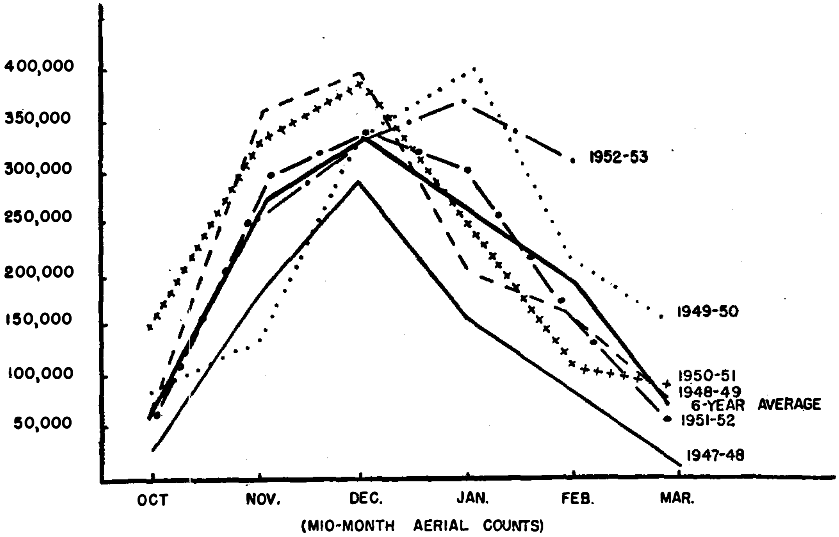

FIGURE 2. YEARLY COUNTS OF DUCKS, BY MONTHS, ON MAJOR WINTERING AREAS IN COLORADO 1947-48 TO 1952-53

Counts have deviated significantly from this pattern in only two out of the six years—1949-50 and 1952-53. The reason for the delay in 1949-50 is not known; however, the late date of the peak in 1952-53 was caused by extreme mild fall and winter weather throughout the Central Flyway, which definitely delayed migration. Actually, there did not seem to be large concentrated flights as usual; rather, the ducks appeared to straggle through in small flights. Thus, they were delayed in reaching their wintering grounds, and peak cocentrations were not recorded until January.

Weekly ground records show that fall migration also occurs in a regular and definite pattern by species each year (Table 1). On the basis of these data, the common species involved have been classified into four catagories in relation to time of movement, as follows:

1. "Early migrants," such as blue-winged teals, begin moving south in August, reach a peak in September, and are largely gone before the hunting season begins.

2. "Mid-season migrants," including gadwalls, shovellers, redheads, lesser scaups, and ruddy ducks; commence moving through northern Colorado in late September or early October, usually reach a peak about the third week of October, and generally are gone by the first to third week of November.

3. "Late migrants," composed mainly of American mergansers and American goldeneyes, start concentrated movement usually the first week of November, peak sometime during the last of November, and, depending upon the date of freeze-up, leave the area by late December.

4. "All-season migrants" and "winter residents," including mallards (the most numerous duck at all time in Colorado), pintails, green-winged teals, and baldpates, begin active migration about the second week of October, reach a peak in movement about the third week of November, and remain as winter residents in the state.

In general, flights during the early fall contain a relatively large percentage of all species common to the Colorado part of the Central Flyway. However, after mid-November, the ducks moving into this region are mainly mallards with smaller numbers of "all-season migrants" and "late migrants" (Table 2). The first large flights enter northern Colorado usually in mid-October and increase to peak numbers in late November and December.

Aerial surveys indicate that in regard to wintering duck populations, the South Platte Valley usually contains the most, the Arkansas Valley ranks second, and the high (8,500 to 9,000 feet) San Luis Valley holds the fewest (Figure 3). This is apparently related to the amount of available water area and food, especially in the northern portion which, again, is reflected in the type and extent of farming practices. Thus, the South Platte Valley grows a variety of crops including corn, small grains, and sorghum, while the Arkansas Valley is mainly a wheat-growing area. Wintering areas in the San Luis Valley are limited by frozen waters, and the ducks which stay are usually found in warm-water sloughs and around artesian wells, which remain open during the winter.

The application of these migration data to present and future hunting regulations is important to the sport of wildfowling. This is especially true when it is realized that the species composition of the bag varies almost directly with the frequency of the birds present in any given area. This conclusion has been drawn mainly from the

TABLE 1. DATES OF MAJOR FALL MOVEMENT, BY SPECIES, 1950, 1951, AND 1952

Species	Year	Major flight dates		
		Begin	Peak	End
Early migrants				
Blue-winged teal	1950	Aug.[1]	unknown[2]	Oct. 3
	1951	Aug.[1]	unknown[2]	Oct. 11
	1952	Aug.[1]	unknown[2]	Oct. 9
Mid-season migrants				
Ruddy duck	1950	Sept. 26	Oct. 3	Nov. 7
	1951	Sept. 20	Oct. 11	Oct. 25
	1952	Sept. 8	Sept. 26	Nov. 6
Gadwall	1950	Oct. 10	Oct. 24	Nov. 7
	1951	Sept. 20	Oct. 18	Nov. 2
	1952	Sept. 17	no definite peak[3]	Nov. 20
Shoveller	1950	Sept. 26	Oct. 24 and Nov. 7	Nov. 30
	1951	Sept. 20	Oct. 11 and Oct. 25	Dec. 12
	1952	Sept. 17	no definite peak[3]	Nov. 20
Redhead	1950	Oct. 3	Oct. 24	Nov. 21
	1951	Sept. 20	Oct. 25	Nov. 8
	1952	Oct. 2	no definite peak[3]	Nov. 20
Lesser scaup	1950	Oct. 24	no definite peak[3]	Nov. 14
	1951	Oct. 18	no definite peak[3]	Nov. 16
	1952		flights very small and erratic	
Late migrants				
American merganser	1950	Nov. 7	Nov. 14	Dec. 27
	1951	Nov. 16	Nov. 21	Dec. 12
	1952	Dec. 11	flights small and erratic	
American goldeneye	1950	Nov. 14	no definite peak[3]	Jan. 18
	1951	Nov. 8	Dec. 5	Dec. 12
	1952	Nov. 13	no definite peak[3]	Dec. 27
All-season migrants and winter residents				
Mallard	1950	Oct. 10	Nov. 30	
	1951	Oct. 18	Nov. 21	remains as winter resident
	1952	Oct. 9	Nov. 6 and Nov. 20	
Pintail (erratic flights)	1950	Sept. 18	Oct. 17 and Oct. 24	
	1951	Oct. 18	Nov. 29	remains as winter resident
	1952	Sept. 17	no definite peak[3]	
Green-winged teal	1950	Oct. 10	no definite peak[3]	Nov. 30[4]
	1951	Oct. 11	no definite peak[3]	Nov. 29[4]
	1952	Oct. 9	no definite peak[3]	Nov. 20[4]
Baldpate	1950	Oct. 10	Oct. 24	
	1951	Oct. 18	Nov. 16 and Nov. 29	remains as winter resident
	1952	flights very small and erratic[3]		

[1]Blue-winged teal migration usually begins in mid-August. Most ducks are then in eclipse plumage and very difficult to count by species.

[2]Blue-winged teal peak believed to occur in September.

[3]Flights of these species either very small in 1952 or normally small each year.

[4]Remains as winter resident. Dates given are of last large recorded flights.

TABLE 2. THREE-YEAR AVERAGE OF WATERFOWL SPECIES BY DATES, NORTH-CENTRAL COLORADO, 1950, 1951, AND 1952

Average observation date	Early migrants[1]		Mid-season migrants[2]		Late migrants[3]		All-season migrants[4]		Total	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Sept. 7	1,026	35.9	141	5.0	....	....	1,687	59.1	2,854	100.0
Sept. 13	213	15.4	46	3.3	....	....	1,126	81.3	1,385	100.0
Sept. 19	92	2.3	977	24.8	....	....	2,880	72.9	3,949	100.0
Sept. 28	150	4.4	448	13.1	....	....	2,822	82.5	3,420	100.0
Oct. 3	144	3.6	522	13.2	....	....	3,306	83.2	3,972	100.0
Oct. 10	45	0.4	1,550	13.4	....	....	9,978	86.2	11,573	100.0
Oct. 17	1	....	3,437	21.1	....	....	12,890	78.9	16,328	100.0
Oct. 24	3	....	3,889	19.9	....	....	15,659	80.1	19,551	100.0
Oct. 31	....	....	945	6.0	35	0.2	14,945	93.8	15,925	100.0
Nov. 7	....	....	1,242	7.8	22	0.1	14,654	92.1	15,918	100.0
Nov. 14	....	....	583	4.1	221	1.5	13,587	94.4	14,391	100.0
Nov. 21	20	0.1	478	2.2	460	2.1	20,780	95.6	21,738	100.0
Nov. 29	....	....	1,029	5.5	179	1.0	17,482	93.5	18,690	100.0
Dec. 5	....	....	77	0.8	104	1.2	8,656	98.0	8,837	100.0
Dec. 12	....	....	291	2.3	17	0.1	12,500	97.6	12,808	100.0
Dec. 19	....	....	....	....	69	0.7	10,304	99.3	10,373	100.0
Dec. 27	....	....	....	....	34	0.6	5,212	99.4	5,246	100.0
Jan. 3	....	....	....	....	38	0.4	9,093	99.6	9,131	100.0
Totals	1,694	0.8	15,655	8.0	1,179	0.6	177,561	90.6	196,098	100.0

[1]Blue-winged teal.
[2]Shoveller, gadwall, scaup, ruddy duck, redhead.
[3]American merganser, American goldeneye.
[4]Mallard, pintail, green-winged teal, baldpate.

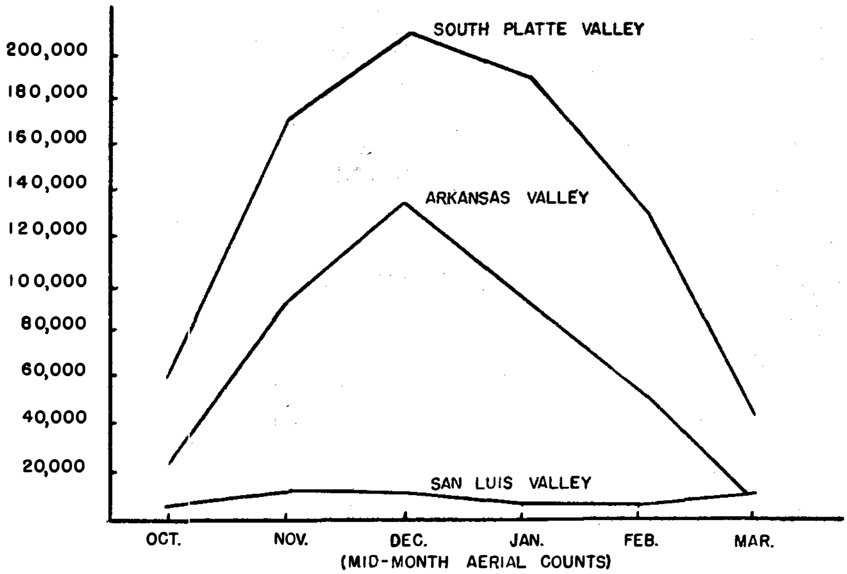

FIGURE 3. SIX-YEAR AVERAGE OF DUCK NUMBERS IN COLORADO, BY LOCATION AND MONTHS, 1947-48 TO 1952-53

examination of hunter's success data collected from three separate sources in Colorado, and which represent three types of hunting: Tamarack Public Shooting Grounds in northeast Colorado, an eastern riverbottom type; a general survey of waterfowl hunters in the Fort Collins area in north-central Colorado, an irrigated valley with numerous lakes, irrigation reservoirs and ditches; and the Mile-High Duck Club near Brighton in central Colorado, a shallow-pond or pothole type.

Data from the Tamarack Public Shooting Grounds and the Fort Collins area, probably the most representative of Colorado conditions, reveal that mallards, on the average, make up about 90 per cent of the bag for seasons usually beginning in mid-October. Closer examination of these totals, by species, before and after November 15 shows that mallards make up only 77 per cent of the bag before, and almost 93 per cent of the bag after this date. Conversely, "mid-season migrants" make up, on the average of the two areas, about 9.5 per cent of the early bag, and 0.5 per cent of the late-season bag. Other species, including other "all-season migrants" and "late migrants," either remained rather consistent in percentage of kill between the two periods or made up a negligible portion of the bag In addition, the green-winged teal, which was the second most common duck bagged at Tamarack, was only of minor importance in the Fort Collins area (Table 3). These data serve to illustrate the difference in mallard kill between early and late seasons which is apparently caused by the early season abundance of other species.

Mile-High Duck Club data substantially confirm the findings of the other two areas; however, since these figures are based on 15-year averages, including some seasons which began in September and others which ended in late December, it is possible to offer a more comprehensive breakdown of species composition in the bag than for either of the other two areas. Admittedly, there is a possible bias in these data due to change in species composition in the population over the years. However, no better indication of species composition of kill is obtainable for seasons held in September and October in Colorado.

The Mile-High data plainly reveal the manner in which species

TABLE 3. AVERAGE SPECIES COMPOSITION OF KILL, BEFORE AND AFTER NOVEMBER 15, TAMARACK RANCH, 1949-1952; FORT COLLINS AREA, 1950-1951

	Kill					
	Before November 15		After November 15		Total	
Species	No.	Per cent total	No.	Per Cent total	No.	Per cent total
Tamarack Ranch[1]						
Mallard	1,970	82.2	4,389	95.2	6,359	91.0
Green-winged teal	313	13.1	129	2.8	442	6.0
Early and mid-season migrants[2]	100	4.2	26	0.6	126	2.0
Late migrants[3]	12	0.5	66	1.4	78	1.0
Totals	2,395	100.0	4,610	100.0	7,005	100.0
Fort Collins Area[4]						
Mallard	315	72.4	643	91.3	958	84.1
Pintail, baldpate, green-winged teal	45	10.3	54	7.7	99	8.7
Early and mid-season migrants[2]	65	14.9	3	0.4	68	6.0
Late migrants[3]	10	2.4	4	0.6	14	1.2
Totals	435	100.0	704	100.0	1,139	100.0
Percentage averages, both areas						
Mallard		77.3		93.3		87.5
Pintail, baldpate, green-winged teal		11.7		5.2		7.4
Early and mid-season migrants[2]		9.6		0.5		4.0
Late migrants[3]		1.4		1.0		1.1
Totals		100.0		100.0		100.0

[1]Data consolidated from Colorado Game and Fish Department Federal Aid Quarterly Reports: January 1950; January 1951; April 1952; April 1953.
[2]Includes mainly gadwalls, redheads, lesser scaups, shovellers, and blue-winged teals.
[3]Includes American mergansers, and American goldeneyes.
[4]Data consolidated from Colorado Cooperative Wildlife Research Unit Quarterly Reports: Vol. 4, No. 3; and Vol. 5, No. 2.

composition in the bag will change with dates of the season, which in turn is correlated directly with the migration pattern of the various species (Table 4). Thus, "early migrants" are bagged early in the fall when they are the most numerous, "mid-season migrants" are bagged mainly in October and early November when the flights of these species come through, and "late migrants" are taken in late November and December at the peak of their migration. "All-season migrants," although always an important component of the bag, are even more so later in the year. This is especially true of mallards. In general, kill figures from Table 4 show trends in kill by species which are very similar to the migration trends given in Table 2.

The data from all studies given above illustrate the potentialities of regulating harvest by manipulation of hunting seasons. Thus, hunting pressure may be placed upon the migrant duck class desired through correct section of hunting-season dates. For example, to reduce the kill of mallards in Colorado, an early season should be selected; or if the "mid-season migrants" should be protected, then a late season should be chosen.

Admittedly, these data may not be important at the present time; however, if hunting pressures continue to increase, it may be necessary in the future to seek adjustment of shooting pressure for given duck species, as described above. Unquestionably, certain species are afforded a high degree of protection at the present time because Colorado bases its recommendations for seasons mainly on mallard flights. The most outstanding example of such protection is the blue-winged teal which, even though the second most common breeder in eastern Colorado and the most common nester in North Dakota, South Dakota, and Nebraska, at least in 1952 (Hjelle, 1952; Murdy and Anderson, 1952; and Miller, 1952), make up only an insignificant portion of the bag during seasons opening in late October. The early migration characteristic of this species is the sole reason for its protection. Undoubtedly an early season, in September, would increase the kill of bluewings at little cost to mallard populations. All of these factors must be given consideration to bring about better and more equitable harvest of the waterfowl resource.

Geese. Geese (*Branta canadensis* spp.) offer fewer problems than ducks in Colorado because they are less numerous and are confined mainly to the extreme southeast corner of the State, mostly on Two Buttes Reservoir. The first large flights of geese are usually counted in mid-November, and the peak occurs in January. By March, these birds have begun their spring movement north to the breeding grounds

TABLE 4. FIFTEEN-YEAR AVERAGE OF KILL BY SPECIES AND WEEKS, MILE-HIGH DUCK CLUB, BRIGHTON, COLORADO, 1922-1930 AND 1945-1953

	Per cent of kill by species and migrant class																	
	Early migrants	Mid-season migrants									Late[1] migrants	All-season migrants					Totals	
Week of season 1922-30 and 1945-53	Blue-winged teal	Gadwall	Shoveller	Scaup	Redhead	Canvasback	Ruddy duck	Bufflehead	Ringneck	Total	American goldeneye	Mallard	Pintail	Green-winged teal	Baldpate	Total	Average number of ducks killed per year	Per cent
Sept. 16-23	30.1	1.0	8.9	....	1.9	....	0.4	....	....	12.2	....	11.7	13.0	31.2	1.8	57.7	508.0	100.0
24-30	25.2	1.8	15.5	0.1	2.4	....	1.0	....	....	20.8	....	6.8	12.2	31.5	3.5	54.0	207.3	100.0
Oct. 1-7	18.1	2.3	19.2	0.6	1.7	....	1.7	....	....	25.5	....	7.5	10.6	34.1	4.2	56.4	197.1	100.0
8-14	16.9	4.0	14.2	0.6	3.4	1.1	1.8	0.2	....	25.3	....	14.0	11.5	29.5	2.8	57.8	264.4	100.0
15-21	8.7	17.5	13.4	1.9	3.3	2.1	1.9	0.6	0.2	40.9	0.1	16.3	9.7	20.2	4.1	50.3	242.4	100.0
22-28	3.1	22.9	10.3	4.8	2.8	1.0	1.4	0.4	0.2	43.8	0.1	27.0	10.0	11.8	4.2	53.0	244.9	100.0
29-Nov. 4	1.4	23.4	9.8	6.2	2.1	1.2	1.6	0.9	0.4	45.6	0.2	34.9	7.6	7.2	3.1	52.8	221.6	100.0
Nov. 5-11	1.2	18.0	9.8	6.6	2.3	0.6	0.8	0.9	0.2	39.2	0.4	42.9	6.5	7.0	2.8	59.2	185.4	100.0
12-18	0.7	11.1	7.2	4.7	1.2	0.5	0.4	0.1	0.5	25.7	0.4	59.2	7.0	5.2	1.8	73.2	129.7	100.0
19-25	0.6	7.8	5.2	3.6	1.2	0.7	0.5	0.5	....	19.5	0.6	66.6	6.9	3.7	2.1	79.3	105.9	100.0
26-Dec. 2	0.3	5.9	3.0	1.7	0.3	0.3	0.1	0.3	0.1	11.7	0.3	76.3	6.6	3.4	1.4	87.7	70.8	100.0
Dec. 3-9	0.4	2.6	6.1	1.7	0.7	0.4	....	....	0.2	11.7	0.6	79.9	4.4	1.9	1.1	87.3	52.8	100.0
10-16	....	0.9	4.6	0.9	....	....	....	....	....	6.4	3.7	84.0	1.2	3.2	1.5	89.9	32.4	100.0
17-23	....	....	....	....	....	....	....	....	....	....	3.3	92.8	0.3	3.3	0.3	96.7	30.7	100.0
24-31	....	0.4	....	....	....	....	....	....	....	0.4	1.7	93.0	....	4.1	0.8	97.9	24.2	100.0
Total season	12.8	9.4	10.8	2.3	2.2	0.6	1.0	0.3	0.1	26.7	0.2	28.2	9.7	19.6	2.8	60.3	2,517.6	100.0

[1]This class also includes the American merganser which apparently was not taken by this club; or if bagged, was not reported.

(Figure 4). The main divergence from this average pattern occurred in 1947-48 and 1952-53. It is believed that hunting pressure during the former year was responsible for the low counts subsequent to the November count; it is known that the low count in December, 1952, was due to the geese being out to feed when Two Buttes was covered. Low fuel, and other commitments, prevented the plane crew from waiting until the geese were concentrated on the reservoir.

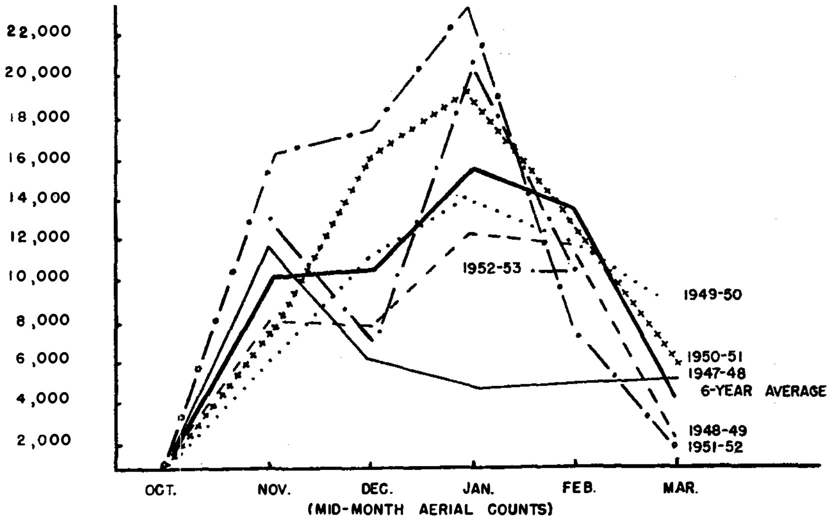

FIGURE 4. YEARLY COUNTS OF GEESE, BY MONTHS, ON MAJOR WINTERING AREAS IN COLORADO 1947-48 TO 1952-53

Location of wintering flocks by area, as given in Figure 5, reveals that the Arkansas Valley always contains more geese than the South Platte Valley. Apparently this area represents the northern-most limits of major goose winter range in the state. The two small peaks in goose numbers (November and February) on the South Platte Valley probably represent migrating flocks, which stopped on their way to, and from, the Arkansas Valley or areas farther south.

It is obvious, from the data presented, that a late hunting season is best from the standpoint of the number of geese present in the state. If is should be desired to curtail the kill of this species, it could be done simply by offering an early hunting season.

Selection of hunting season dates and associated problems. Colorado, because of its topography, offers a unique problem in establishing waterfowl-season dates that meet the approval of all sportsmen. In

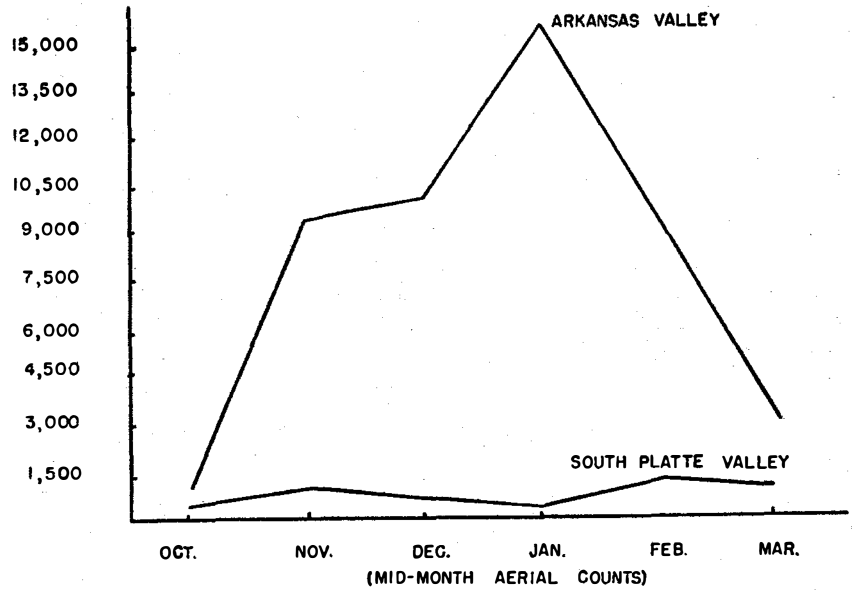

FIGURE 5. SIX-YEAR AVERAGE OF GOOSE NUMBERS IN COLORADO, BY LOCATION AND MONTHS, 1947-48 TO 1952-53

altitude, streams and lakes occur from above timberline to the lower plains, a variation of 8,000 feet. The problem, therefore, is mainly one of freezing waters. Considering the high mountain parks and valleys, where waters are almost always frozen by November 1, waterfowl hunting is restricted to two or three weeks at best during the early part of the season. In addition, the "pothole" hunters on the eastern plains, immediately adjacent to the foothills, also freeze out early in the season. Though hunters in these regions are in the minority, they are nevertheless penalized by the latter opening date necessary to catch the northern flights of mallards in the eastern half of Colorado, where the majority of waterfowl hunters reside. This late opening date is also necessary to meet the desires of goose hunters who come from near and far to the concentrations in southeast Colorado.

Another factor which must be given consideration is that of crop depredation. In certain areas, during some years, this problem can become critical, especially in years of labor shortages or early storms when corn and sorghum crops cannot be harvested (Wagar, 1946). Since mallards are the worst offenders, a late season would probably help most to alleviate this condition.

Considering all these factors—migration dates, freezing waters, hunting pressures, and crop depredation—it is usually desirable, with a season of 45 days or more, to select a straight season beginning the third week in October running into December. However, with a season of less than 45 days, a split season would more nearly meet all problems; the first half should begin in mid-October and the second half in early or mid-December.

All of these factors are carefully considered when recommendations for season dates are submitted by the Colorado Game and Fish Commission to the U. S. Fish and Wildlife Service. Thus, all hunters obtain some shooting, and the majority are generally satisfied with the results.

SUMMARY

1. Mid-month aerial counts covered the six-year period 1947-48 to 1952-53, and were conducted on the main waterfowl wintering areas in Colorado. This sample included more than 460 miles of river and 40 large reservoirs in the South Platte, Arkansas, and San Luis valleys.

2. Weekly ground migration counts were conducted on five large reservoirs in north-central Colorado for the purpose of obtaining migration information by species.

3. Aerial methods consisted of flying the rivers and lakes ,ecording the number of ducks and geese. When the lakes were frozen, with large numbers of ducks concentrated in the center, total numbers had to be estimated.

4. Ground counts on large reservoirs were made with a 20-power spotting scope. When numbers were two or three thousand or less, the ducks were counted individually by species. A system of estimation was used on large flocks, accomplished by counting several scope-fields, by species, then applying this average to the total number of scope-fields in the raft.

5. On the average, there is a steady influx of ducks into Colorado beginning in September, with large flights usually occurring in late October. Peak populations normally occur in December, and numbers taper off after this time until late February or early March, when the thaw occurs and first spring movement begins.

6. Weekly ground records show that fall migration occurs in a regular and definite pattern, by species, each year. On the basis of these data, the common species have been classified into four categories in relation to time of movement: "Early migrants," blue-winged teals; "mid-season migrants," gadwalls, shovellers, redheads, lesser scaups, and ruddy ducks; "late migrants," American mergansers,

and American goldeneyes; "all-season migrants" and "winter residents," mallards, pintails, baldpates, and green-winged teals.

7. Aerial surveys indicate that the largest number of ducks winter in the South Platte Valley, the second largest number in the Arkansas Valley, and the smallest number in the San Luis Valley.

8. Hunting-success studies show that the trend in species composition in the bag is very similar to the species migration pattern. Thus, "early migrants" are bagged early in the fall; "mid-season migrants" are taken in October and early November; and "late migrants" are shot in late November and December. "All-season migrants," always important in the bag, are even more so late in the season.

9. It is believed that hunting pressures, through manipulation of open dates, may be applied to the class of ducks desired. For example, to reduce the kill of mallards in Colorado, an early season should be selected; or if it was sought to protect "mid-season migrants," a late season should be chosen.

10. Certain species are now afforded virtual protection because Colorado bases its season recommendations on mallard flights. The best example of such protection is the blue-winged teal, which makes up only a minor portion of the bag during seasons beginning in late October, even though it is an important nesting duck in eastern Colorado, North Dakota, South Dakota, and Nebraska.

11. If waterfowl hunters continue to increase, it may be necessary, in the future, to seek adjustment of shooting pressures for certain species to effect a more equitable harvest of the waterfowl resource.

12. The first large flights of geese usually arrive in Colorado during mid-November, with peak numbers occurring in January. By March, these birds have begun their spring movement north to the breeding grounds.

13. Large wintering flocks of geese occur mainly in the Arkansas Valley of Colorado. Geese counted in the South Platte Valley usually represent migrating flocks moving to and from areas farther south.

14. Factors that must be considered by the Game and Fish Commission in selecting hunting season dates for Colorado are: migrating peaks; differential freezing of waters; hunting pressures; and crop depredation.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to Director Thomas L. Kimball, Federal Aid Coordinator Laurence E. Riordan, and Game Manager Gilbert N. Hunter, Colorado Game and Fish Department, who gave strong support to this project. We are grateful also to Mr. Robert G. Kinghorn for his excellent job of setting up and operating the original aerial survey. Our further thanks are due E. K. Brown, Albert E. Carlson, Harry J. Figge, Kenneth B. Milyard, Ferd C. Kleinschnitz, W. L. Flinn, Harold M. Swope, Norman L. Hughes, Clyde P. Matteson, Dwight Owens, and Harold M. Boeker, who either supervised the work or assisted in the collection of the data.

Mr. Samuel S. Sherman Jr., President, Mile-High Duck Club, graciously permitted the use of Mile-High records. Boyd Evison, senior game management student, Colorado A & M College, compiled the Mile-High data.

We especially acknowledge the assistance and advice of Dr. Lee E. Yeager, Leader, Colorado Cooperative Wildlife Research Unit, in the preparation of this paper.

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DISCUSSION

MR. CALHOUN: Don't tell me I'm going to have to ask the first question again. Perhaps I can get the ball rolling again by asking what will probably be an embarrassing question.

Your migration studies have shown that you need an earlier season because of the teal, and a later season because of the mallards. How do you propose to get around that?

MR. GRIEB: That is a good question, one that we cannot resolve at the present. We are still going to have to base our seasons on the mallard flights, because that is the duck the sportsmen want to shoot.

We are not putting any hunting pressure on the early migrant species. That is something that, at the present time, we have nothing to say about.

MR. DAVID MONRO (Canadian Wildlife Service): I was interested in the plight of the hunters in Colorado who reside in the areas of high elevation. You will understand that in parts of Canada we are faced with much of the same problem. Freeze-up comes along and cuts off the end of the season, very often before too much of it has elapsed. Sportsmen being what they are, they very often base their representations for one season on the conditions of the year just past, with the consequence that there is a considerable variation in the requests for dates for various areas open.

You might be interested to know that we are seeking to accumulate and evaluate data on freeze-ups in various parts of the country for a very long period of time, in order that we can provide some sportsmen the information as to when it is most likely that their season ends through natural means, thus eliminating some of the annual quibbling based on last year's experiences that frequently goes on.

FIELD OBSERVATIONS OF GEESE IN JAMES BAY, WITH SPECIAL REFERENCE TO THE BLUE GOOSE[1]

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Since the seventeenth century, when the first Hudson's Bay Company fort was established at Rupert House, Quebec, white and native residents of the James Bay area have used geese as an essential seasonal supply of food. Until comparatively recently the isolation of the area from other settlements protected the geese from excessive exploitation. With the development of the country, the building of the railroad from Cochrane to Moosonee in 1932, and the modern use of airplanes the area is now readily accessible, and many white hunters annually visit James Bay for the goose hunting.

Because of increasing utilization of this resource it is considered desirable to review the situation at this time. An officer of the Canadian Wildlife Service has visited the James Bay area each autumn since 1946 to make biological and other observations during the hunting season. The data included in this paper are based on the observations of those men, including the writer, who visited James Bay during the autumns of 1948, 1949 and 1952.

THE GEESE OF JAMES BAY

As will be shown later, the blue goose (*Chen caerulescens*) is the species that is most abundant in southern James Bay during September and October of each year. This species is confined to North America, and practically all of the blue geese in the world are present in some region of James Bay in the autumn. It is largely because of this fact that the situation there is being so carefully studied.

The blue geese arrive in southern James Bay from their more northern nesting grounds about September 10. Between mid-September and mid-October the flocks of geese gradually increase until the maximum numbers are usually present by October 18. Even before that date, however, some flocks have left the Bay for the south, and nearly all have gone by the end of October. Their exit depends upon the date of freeze-up.

The geese congregate, in large or small flocks, mainly along the estuaries of the larger rivers and in the mouths of the smaller rivers and creeks emptying into James Bay. Here they feed and rest on the wide expanses of tidal flats.

[1]In the absence of Mr. Stirrett this paper was read by Mr. Louis Lemieux.

TABLE 1. SHOWING PERCENTAGE OF EACH SPECIES OF GOOSE IN TOTAL POPULATION OF SOUTHERN JAMES BAY DURING SEPTEMBER AND OCTOBER

	1948	1949	1952	1953
Blue Goose	94	91	95	95
Lesser Snow Goose	4	3	4	5
Common Canada Goose	2	6	1	....[1]
Number of geese in sample	700	500	8,575	10,928

[1]Not counted.

Hewitt (1950), a former member of the Canadian Wildlife Service, who was present in James Bay during the autumns of 1946 and 1947, has discussed the early observations made in the area. His paper is illustrated by an excellent map, to which the reader is referred.

The goose population of James Bay during September and October is made up mainly of three species of geese. The following table indicates that blue geese comprise from 91 to 95 per cent of the total numbers, with lesser snow geese usually forming the majority of the remainder. The method used was the counting of small family flocks on the ground; similar species ratios were obtained by counting or estimating large flocks from the air.

In addition to the three species indicated, American brant (*Branta bernicla*) are also found in the area, but not in the territory in which shooting is allowed. They are found mostly on Charlton and adjacent islands, and on the eastern mainland at Paint Hills. The present brant population is approximately 3,000 birds. The population counts given in Table 1 were made on the mainland within or adjacent to areas open to hunting.

This paper treats the lesser snow goose, *Chen hyperborea hyperborea* of American authors, as a species distinct from the blue goose, *Chen caerulescens*. The common Canada goose is *Branta canadensis*.

In dealing with blue geese it is much easier and more profitable to count or sample family flocks, as it gives more time for the recognition and recording of flock components. Counting family flocks has been a standard procedure in all studies dealing with this species.

The juvenile-adult ratio, as Hewitt (1950) pointed out, provides an index of comparative breeding success from year to year. The error

TABLE 2. PERCENTAGE OF ADULTS AND JUVENILES IN BLUE GOOSE POPULATION, SOUTHERN JAMES BAY REGION

	1946	1947	1948	1949	1950	1951	1952	1953
Adults	67	73	40	35	57	60	39	41
Juveniles	33	27	60	65	43	40	61	59
Ratio: Juveniles to Adults	1:2.0	1:2.75	1:0.66	1:0.54	1:1.34	1:1.52	1:0.63	1:0.65
Number of geese in sample	2,300	16,900	700	500	2,589	672	8,145	10,928

introduced by the presence of non-breeding birds, if any, is thought to be small. Non-breeders cannot, of course, be recognized in the autumn migrating flocks, and the determination of their number will have to await identification of the breeding grounds of the James Bay populations. When that is known, observations on the breeding grounds could supply a correction factor.

Our records show that breeding success, as indicated by the juvenile-adult ratio, has varied from year to year. 1947 was the poorest year for production of young. 1946 and 1951 were also poor years. The best breeding success was in 1949. The last two years, 1952 and 1953, have been favorable breeding years. The factors which are responsible for variations in breeding success cannot be determined until we identify and study the breeding grounds of the James Bay populations of blue geese.

The composition of recognizable family flocks of blue geese, that is, the number of adults and young in a sample of 1,343 families observed in 1952, is shown in Table 3.

Table 3 indicates that about 9 per cent of the family groups included only one adult, and about 2 per cent had no adult. The family

TABLE 3. COMPOSITION (ADULTS AND YOUNG) OF BLUE GOOSE FAMILY FLOCKS IN JAMES BAY, 1952

Type of Families		Numberof Families	Per Cent of Total Flocks.	Total Adult	Total Young	Totals
0 Adults With	— 2 Young	5	0.37	0	10	10
	— 3 Young	7	0.52	0	21	21
	— 4 Young	7	0.52	0	28	28
	— 5 Young	4	0.30	0	20	20
	— 6 Young	2	0.15	0	12	12
	Subtotal	25	1.86	0	91	91
1 Adult With						
	— 1 Young	9	0.67	9	9	18
	— 2 Young	34	2.53	34	68	102
	— 3 Young	37	2.75	37	111	148
	— 4 Young	30	2.23	30	120	150
	— 5 Young	10	0.74	10	50	60
	— 6 Young	5	0.37	5	30	35
	— 7 Young	0	0	0	0	0
	— 8 Young	1	0.09	1	8	9
	Subtotal	126	9.38	126	396	522
2 Adults With						
	— 0 Young	41	3.05	82	0	82
	— 1 Young	66	4.91	132	66	198
	— 2 Young	272	20.25	544	544	1,088
	— 3 Young	398	29.63	796	1.194	1,990
	— 4 Young	249	18.54	498	996	1,494
	— 5 Young	107	7.97	214	535	749
	— 6 Young	40	2.98	80	240	320
	— 7 Young	15	0.99	30	105	135
	— 8 Young	4	0.44	8	32	40
	Subtotal	1,192	88.76	2,384	3,712	6,096
	Total	1,343	100.00	2,510	4,199	6,709

TABLE 4. PERCENTAGE OF EACH SPECIES IN WHITE HUNTERS' BAGS, JAMES BAY REGION, 1948 TO 1953

	1948	1949	1950	1951	1952	1953
Blue Goose	94	90	92	97	95	95
Lesser Snow Goose	4	5	7	2	4	5
Canada Goose	2	5	1	1	1	....[1]

[1]Not recorded.

group occurring with the greatest frequency, comprising 29.6 per cent of the number of families and 29.7 per cent of the number of individuals, consisted of two adults with three young. The largest families observed contained two adults and eight young.

GOOSE HUNTING AND HARVEST OF GEESE

Table 4 gives data obtained from examination of white hunters' bags of geese, and shows that the various species are killed in about the same ratio as that in which they are available.

The number of Canada geese shot in 1953 was not recorded, so there is a slight error in the percentage figures for that year, which are based on a count of blue geese and lesser snow geese only.

The total kill of blue geese for a number of years has been estimated, and is given in Table 5.

The figures given for the white hunter kill, which reached a peak of 4,082 in 1951, are as accurate as possible. In most years a large majority of the birds killed by whites were actually counted. The native Indian kill, averaging about 75,000, is estimated on the basis that there are 800 native hunters in the area, each securing 100 geese in a season. An adjustment is made for the proportion of blue geese in the total available goose population each year.

The Indian population of the James Bay district is approximately 4,500. These people rely to a large extent, as their ancestors did for centuries past, on the geese for essential food. There is no waste, and all parts of the bird except the primaries are utilized. Many birds are preserved by smoking or salting and thus provide a food supply long after the geese have left the area.

The present harvest of blue geese in James Bay is considered to be well within the limits that can be tolerated by the species, on the basis

TABLE 5. ESTIMATED TOTAL KILL OF BLUE GEESE. JAMES BAY AREA, FOR YEARS 1948 TO 1953, INCLUSIVE

	1948	1949	1950	1951	1952	1953
No. killed by white hunters	2,025	3 600	2,810	4.082	2,962	3.963
Estimated No. killed by native Indians	75.200	72.000	73,600	77,600	76,000	76.000
Estimated Total Kill	77,225	75,600	76,410	81,682	78,962	79,963

TABLE 6. PERCENTAGES OF ADULT AND IMMATURE BLUE GEESE SHOT BY WHITE HUNTERS IN JAMES BAY AREA

Age	1948	1949	1950	1952	1953
Adult	30	33	47	24	43
Immature	70	67	53	76	57

of known population level and known kill in other sections of North America.

Table 6 gives percentages of adult and immature blue geese examined in white hunters' bags, and should be compared with Table 2, which gives corresponding data for the living flocks. In the years 1949 and 1953 the percentages indicated in the two tables are almost identical. In spite of any bias on the part of individual hunters towards taking either young birds or adults, it appears that hunters take adult and immature birds in much the same proportion in which they occur in the general population.

Adequate data on the sex of blue geese shot are available for only three years, 1949, 1952, and 1953. The percentage of male birds varied from 48 in 1949 to 53 in 1953. If, as appeared from age distribution of the birds shot, hunters take birds according to their availability, those figures indicate that the sexes of the blue goose in James Bay are fairly evenly balanced. Males and females appear to be equally vulnerable.

During the years under study, there has not been recorded a case of a hunter taking more geese than the law allowed. All hunting areas are strictly supervised by members of the Royal Canadian Mounted Police. Some geese, of course, are eaten in camp and the rest are shipped out by the hunter. Two-thirds or more of the hunters are United States residents, and the remainder Canadians.

During two seasons (1949 and 1952) the gauge of gun and size of shot used by each white hunter visiting the area were recorded. The size of shot, particularly, was of interest, because early observations indicated that shot of too small a size was being used by most hunters and causing heavy crippling losses. The managers of Hudson's Bay Company stores and officials of organized hunting camps were asked to recommend heavy shot and heavier-gauged guns. The tendency now, as shown in Tables 7 and 8, is toward a greater use of number 2 shot, and 12-gauge shotguns.

THE WEIGHT OF THE BLUE GOOSE

During the goose hunting season of 1952, Dr. Stirrett and Mr. Graham Cooch took physical measurements of some 307 blue geese, including the weight of 272 of the birds. These were secured from

TABLE 7. GAUGE OF SHOTGUNS USED BY JAMES BAY WHITE HUNTERS, BY PERCENTAGES

Gauge	1949	1952
10	0	0
12	78	94
16	18	4
20	4	2

many sections of southern James Bay. As little information on the weight of the blue goose has been published, the records are given in Table 9. The average weight of an adult male was 6.13 pounds, with a range from 5 to 7¼ pounds. The average weight of an adult female was 5.47 pounds, with a range from 4½ to 6½ pounds.

There is some indication from the weight records that blue geese gain weight during their stay in the James Bay area. The average weight of 48 geese taken from September 20 to 22 was 4.82 pounds, while the average weight of 43 geese taken from October 9 to 11 was 5.57 pounds. Although most of the sample was made up of juveniles, which one could expect to gain weight as they matured, the few adults in the sample showed an even larger gain in weight than did the juveniles. More data, however, are needed before a definite statement can be made on this point.

BLOOD PARASITES OF BLUE GOOSE

During 1952 Dr. Stirrett and Mr. Cooch took blood smears from 136 blue geese. The slides were processed and examined by Dr. A. M. Fallis, Ontario Research Foundation, Toronto. Dr. Fallis found all slides free of blood parasites, except one, which contained specimens of a long form of *Microfilaria* spp. The blue goose carrying those parasites was an adult male, collected at Hannah Bay on October 8. It is interesting to note that the only Canada goose from which blood was secured (Hannah Bay, Sept. 18) was infected with a short form of *Microfilaria*. The blood of seven lesser snow geese did not show parasitism.

TABLE 8. SIZE OF SHOT USED BY WHITE HUNTERS IN JAMES BAY, BY PERCENTAGES OF USERS

Size of Shot	1949	1952
2	2.	45.
3	0.	0.5
4	87.	40.
5	9.	11.
6	2.	4.

TABLE 9. WEIGHT IN POUNDS OF BLUE GEESE, ACCORDING TO AGE AND SEX, JAMES BAY REGION, 1952

Males	Number Weighed	Average Weight (Pounds)	Weight Lightest goose in class	Weight Heaviest goose in class
Adult	36	6.13	5.00 (2)	7.25 (2)
Yearling	3	6.08	5.25	6.75
Juvenile	98	5.20	3.50	7.00
All Males	137	5.46	3.50	7.25
Females				
Adult	29	5.47	4.50 (4)	6.50 (3)
Yearling	9	5.42	4.25	6.25
Juvenile	97	4.90	3.00 (2)	6.25
All Females	135	5.05	3.00 (2)	6.50 (3)
All Blue Geese	272	5.25	3.00 (2)	7.25 (2)
All Adults	65	5.83	4.50 (4)	7.25 (2)
All Yearlings	12	5.58	4.25	6.75
All Juveniles	195	5.05	3.00 (2)	7.00

(Figures in parentheses indicate number of specimens at that weight.)

EXTERNAL PARASITES OF BLUE GOOSE

During 1952, while taking physical measurements of 307 blue geese and 19 lesser snow geese, Dr. Stirrett and Mr. Cooch were on the watch for external parasites. Most birds were apparently free from lice; certainly none was heavily infested. The following lice were collected: from blue geese, *Trinoton anserinum, Anatoecus* sp., and *Anaticola anseris;* from lesser snow geese, *Trinoton anserinum* and *Anaticola anseris. Anaticola anseris* was by far the most abundant of the three species found. All Mallophaga were identified by Dr. E. W. Stafford of Mississippi State College.

HYBRIDS BETWEEN BLUE AND LESSER SNOW GOOSE

Hybrids between the blue goose and the lesser snow goose are well known, and in fact many authorities believe the two types to be color phases of one species. It is not our present intention to enter into this controversy, but some of the observations made in James Bay might add to understanding of the problem.

Certain family flocks observed were made up of typical blue geese and typical white geese, or of birds light enough or dark enough to be classed as one or the other, and yet acting as one family. During 1952 such mixed flocks formed 9 per cent of the 1,650 flocks observed. In 1953 they formed 10 per cent of the 2,225 flocks observed.

Of 307 blue geese examined in 1952, 98 birds, or 32 per cent, showed some signs of hybridization. Those birds had more white in the plumage than has a typically colored blue goose.

PLANT ASSOCIATIONS AND GOOSE HABITATS

The type of habitat utilized by blue and other geese for feeding and loafing does not vary greatly throughout southern James Bay. The tidal flats tend to have the same dominant plants or groups of plants and the same ecological plant zonation from shoreline vegetation to marsh, to willow and to taiga.

The tidal flats of cabbage willows, which are typical of most of the area, surround Rupert Bay in a wide curve with nearly 16 miles of shoreline. At the bottom of the curve, where Cabbage Willows Creek enters the Bay, the flats extend inland to a depth of about four miles. They are crossed by innumerable creeks and natural ditches which fill with water at each high tide.

During September and October the flats are frequented by large numbers of geese. In 1952 at the height of the season the goose population was estimated to be from 10 to 12 thousand.

At least twice a year, with extremely high tides (7 to 10 feet), the entire flats are covered with water back to tree line, which here is the beginning of taiga. Usually the shoreline vegetational zone is covered at each high tide, but the marsh zone may also sometimes be covered. Goose hunting takes place in those two zones, and therefore may be an extremely wet proposition. Frequently blinds and even temporary camps may have to be moved inland if the tide is slightly higher than usual. The shoreline vegetational zone and the marsh zone are devoid of even small trees, and materials for building blinds have to be procured in the willow vegetational zone and carried out to the hunting location, sometimes as much as two or three miles.

The shoreline vegetational zone is dominated by those amphibious halophytes which are able to withstand wave action and flooding at each high tide. The usual plants of this zone are *Hippuris tetraphylla, Eleocharis halophyla, Salicornia europaea, Scirpus paludosus* var. *Atlanticus,* and *Scirpus americanus.* Frequently there are large or small areas of pure stands of each of these plants; at other times they are mixed. Their height varies from 8 to 12 inches.

The second zone inland is that of the tidal marsh. It may or may not be flooded at each high tide. Here the most important plants are *Equisetum variegatum* and *Scirpus paludosus* var. *Atlanticus, Scirpus validus* var. *Creber, Eleocharis halophila, Carex paleacea, Carex aquatilis, Carex salina, Potentilla anserina, Galium trifidum, Thalictrum dasycarpum, Senecio congesta, Solidago altissima.*

The willow zone is dominated by three species of willows, *Salix bebbiana, Salix candida,* and one species not yet determined. The same herbaceous plants may occur here as are found in the marsh zone, but the willow zone is drier most of the time, and the halophytes drop out to be replaced to a large extent by such genera as *Thalictrum, Ligusticum, Rhinanthus, Solidago* and *Aster*. Here also are found wild roses, *Prenanthes racemosa, Circium muticum, Anemone* sp. and the grasses, *Calamogrostis neglecta* and *C. canadensis*. This latter grass frequently occurs in pure stands of large extent.

The fourth zone from the sea side is the forested area, which here forms the true taiga. The trees are mostly black spruce and tamarack. Except for a narrow stand along river banks, the trees form scattered clumps interspersed with small or large areas of bogs and muskeg.

The geese prefer the tidal flats and are found most frequently in the shoreline and marsh zones. They rarely fly inland and use the taiga, unless there is a favorable lake in the neighborhood. The geese show the usual flight-activity periods in morning and late afternoon, but the flights are generally along the coast and not inland.

THE FOOD OF BLUE GOOSE

The crop contents of 106 blue geese were collected at various locations. The examination and analysis of these have not been completed, but enough has been done to indicate that the chief foods of the blue goose in the James Bay area are the following plants:—*Equisetum variegatum, Scirpus paludosus* var. *Atlanticus, S. americana, Carex paleacea, C. salina,* and a species of *Carex* which is still unidentified but belongs to the division *acutae* and is probably *C. aquatilis*.

SUMMARY

Basic biological and other observations on the geese of James Bay, with special reference to the blue goose, are presented in this paper. These are the results of observations made by six members of the Canadian Wildlife Service who studied in the area during the period 1946 to 1953.

The goose population of the James Bay area comprises from 91 to 95 per cent blue geese, 3 to 5 per cent lesser snow geese, and from one to 6 per cent Canada geese. American brant also occur in the area in very small numbers.

Family relationships, juvenile-adult ratios, breeding success, sex ratios, weights, blood parasites, and external parasites of the blue goose are given for a number of years.

Hunting statistics which are discussed include: proportions of species in hunters' bags, which show that geese are taken according to their availability in the area; total harvest of blue geese by white and native Indian hunters; age and sex of blue geese shot; records of gauge of guns used and size of shot. The present harvest of blue

geese in the James Bay area is well within the limits which the known population level will tolerate, taking into account the known kill from other sections of North America. Data obtained on hybridization between blue goose and lesser snow goose are given.

The plant associations inhabited by geese are designated and their dominant plants named. Finally the chief food plants of the blue goose in James Bay are given.

ACKNOWLEDGMENTS

The officers of the Canadian Wildlife Service who were in the James Bay area and whose observations and reports have been used in compiling this paper are:—for 1946 and 1947, Dr. O. H. Hewitt; for 1950, Mr. J. S. Tener; for 1951, Mr. R. D. Harris, for 1953, Mr. L. Lemieux. The writer, as stated previously, was in the area in 1948, 1949 and 1952. Mr. Graham Cooch was there in 1952 and 1953. The writer wishes to thank these, his colleagues, for permission to use their reports.

It would be utterly impossible to work in an area such as James Bay without the cooperation of the residents and the organizations situated there. The managers of the various posts of the Hudson's Bay Company were particularly helpful to all members of the Canadian Wildlife Service doing a tour of duty in the area. Special thanks should be given to Mr. Ronald Duncan, former manager of the Moose Factory post and to Mr. W. A. Buhr, its present manager.

The owners and mangers of the organized hunting camps in the James Bay area were very helpful, and it is a pleasure to thank them for all their courtesies. These men are:—Colonel C. E. Reynold and Colonel Walter Johnson of the Ontario Northland Railway camp at Hannah Bay; Mr. C. S. MacLean, who has a private camp on the Nottaway River; Mr. Tom Wheeler of Cabbage Willows Camp; and Mr. Len Hughes, who owns hunting camps at the mouth of the Albany River.

The pilots of Austin Airways Ltd. gave assistance in many ways beyond their business of air transport. Special thanks are due to pilots Messrs. Blakely and Charity.

Mr. J. S. Allen, Moose Factory, local Indian agent of the Department of Citizenship and Immigration, also gave cooperation which is gratefully acknowledged.

Without the assistance of the Royal Canadian Mounted Police these investigations would have been most difficult to carry out.

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DISCUSSION

MR. MARTIN BOVEY (Martin Bovey Films, Chelmsford, Mass.):

In the course of making a motion picture film, during the years 1935, '36 and '38, I spent a bit over two months on the coast of James Bay among the blue geese. I want to take issue with the size of shot that is recommended in the paper.

I always use No. 6 shot. I have very few cripples. When I return to hunt blue geese on James Bay again, I'm going to use 7½. I say that for several reasons. No. 7½ is my favorite waterfowl load when shooting anything, including Canada geese over decoys. Large shot encourages shooting at outrageously long ranges, and I have certainly demonstrated to my satisfaction—through my own personal shooting and through watching others—that it results is an infinitely larger number of seriously crippled birds and loss of dead birds than does the shooting of small shot. You have a very bad pattern with No. 2 or No. 4 in the ordinary gun. You have a much tighter and infinitely better pattern with No. 6, and generally a still better pattern with the 7½.

The result is that your No. 2 or No. 4 will probably land one shot in some portion of the bird, or possibly two or three, tearing a good sized, gaping hole, so that the bird will bleed freely at a considerable distance, and when he is where you have little or no chance of retrieving him, he will very likely fall dead.

If you will shoot 6's—or, preferably, 7½'s—and if you center your bird at all, you will land several pellets in his neck or head, you'll hit him with probably 20 or 25 pellets. If that does not kill him, certainly the shock is enough to bring the bird down instantly so you can retrieve him.

As I said, if I were ever to shoot on James Bay again for blue geese and Canada geese, I would use 7½ shot, whether the gun was a .410 or a 12. I would shoot either gun on decoying birds, and I make no claims whatsoever to being anything other than an extremely mediocre shot. I have always prided myself on being able to go home at the end of the day and say that I have not left one seriously crippled bird anywhere in the marsh. If you shoot the small shot and catch the bird on the end of the pattern, he is probably not very badly hurt.

MR. LEMIEUX: Thank you.

As you know, I didn't write this paper. I simply read it. I was in James Bay, too, this last season, and I have to agree entirely with the last two remarks. I don't know how George Stirrett figured out that the heavy shot would be better. I did a little shooting. I was using size 6, which was very good, especially when you consider that you have those Indian guides up there who are very effective in bring in the geese right down to your blind.

I think it is a very sound idea to use either 6 or 7½, and simply to wait for the guide's signal as to when to shoot. I guess in that way we probably do not cripple as many birds.

MR. BOVEY: May I say one more word? Those of us who are interested in conservation couldn't do a greater service for the waterfowl of the country—couldn't do more to reduce the appalling crippling loss—than by encouraging the gunners of both nations, and Mexico, to shoot smaller shot instead of encouraging the boys to shoot bigger shot.

MR. CALHOUN: Thank you. Are there any more questions?

LT. RICHARD W. HESS (University of Maine, Orono, Maine): In your talk you mentioned the aerial observation of the ducks on the bay. I have two questions.

What specific area-of-observation methods did you use? Did you use the aerial photograph in counting the number of birds in the raft?

MR. LEMIEUX: No, we didn't use aerial photographs. This air survey was simply conducted whenever the occasion would arise—that is, whenever we would travel from one hunting camp to another, most of the time by plane. On those travels we would simply make a note of whatever birds we saw. We were mostly interested, then, in the composition of the flocks, as to blue geese and lesser snows. We were simply trying to get the percentage of blues and snows in the area, but there was no system used.

THE EFFECT OF CHANGED ANGLING REGULATIONS ON A TROUT POPULATION OF THE AU SABLE RIVER

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The North Branch of the Au Sable River, lying about 200 miles north of Ann Arbor in Michigan's Lower Peninsula, has long been regarded as one of the state's better brook trout streams. Originally the Au Sable drainage was noted for its grayling fishing (from which the town of Grayling on the main stream derived its name). The grayling decline began in about 1880. In an effort to replace the grayling, the Michigan Fish Commission planted 20,000 brook trout (*Salvelinus fontinalis*) fry in the Main Au Sable in March, 1885. Introduction of brown (*Salmo trutta*) and rainbow (*Salmo gairdneri*) trout fry followed by 1891.

The early brook trout plantings soon provided excellent fishing in the North Branch. In 1900, according to Mershon (1923, p. 165), of 1,038 trout taken by him and his guests during the period May 12-14, all were brook trout except four rainbow trout. By 1926, the ratio of brook trout to rainbow trout had changed to 4:1 (personal communication from Milton P. Trautman). In 1937-1940 the species ratio in anglers' catches was about five brook trout to one brown trout; few rainbow trout were observed. In the 1950-1953 period, partial creel census records for the stream sections with unchanged regulations (discussed later) suggest a species ratio of 2.7 brook trout to 1 brown trout.

The brook trout, however, is the favorite species of the North Branch fisherman, and the gradual decline in numbers of large specimens and catchable fish per angler since 1900 has prompted various regulations to renew the fishing of the early days. Between 1903 and 1927 the daily bag limit was reduced from 50 to 15 trout. An 8-inch minimum size limit was prescribed during two diferent periods, and lures were restricted to artificial flies during six different years. Stream improvement devices were installed in parts of the stream in 1934-1935, and again in 1949-1950, in an effort to rehabilitate the angling.

From 1928 to 1948 the regulations governing trout fishing on the North Branch were the same as those in force on other Michigan trout streams, namely: daily creel limit, 15 trout; minimum size limit, 7 inches; natural and artificial lures were permitted; the trout season length was the same as for other Michigan brook trout waters.

There are no data available for the early days of the century from

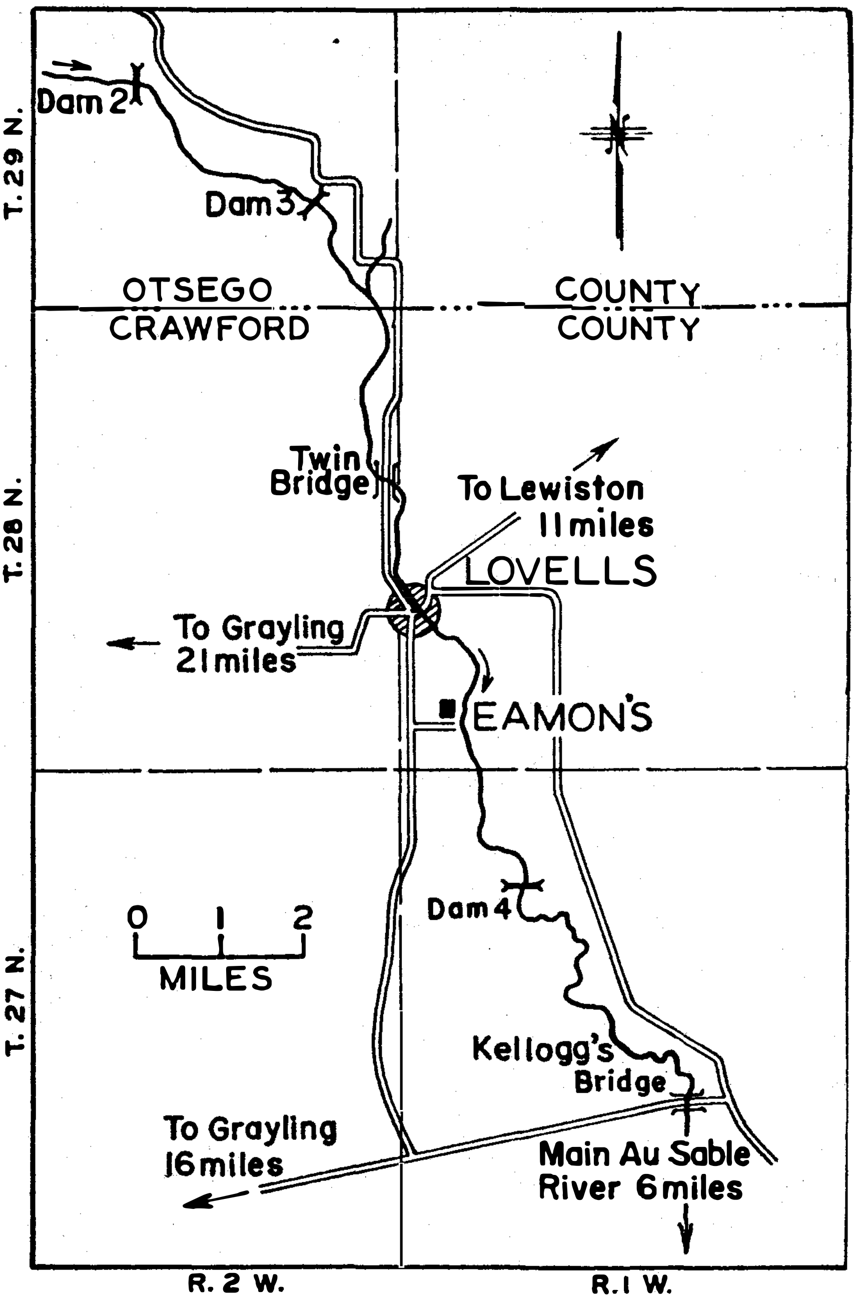

Figure 1. North Branch of the Au Sable River (Crawford and Otsego counties, Michigan), traced from Michigan Department of Conservation County Maps.

which reliable indices of angling quality can be computed. The earliest creel census records covering a large enough series of angling trips were obtained during 1937-1940 by Civilian Conservation Corps enrollees directed by Conservation Department personnel. A 4.6-mile stretch of the North Branch, extending from the Crawford-Otsego county line to the Lovells Bridge (Figure 1), was observed daily during the trout season between 6 a. m. and 9 p. m. Records of all fishing trips were tallied, and as many fishermen as possible were contacted personally to secure pertinent fishing records. During 1937-1940, total angling trips varied between 1,622 and 2,556 trips. The observed catch ranged between 2,095 and 3,143 trout; about five-sixths were brook trout. Catch per hour indices fluctuated from 0.33 fish in 1940 to 0.48 fish in 1938. The percentage of successful trips, chronologically, was 47, 48, 37 and 37. In this period anglers expended between two and three hours of effort for each legal trout removed. The yearly average size of brook trout taken was between 7 and 8 inches, while brown trout yearly average sizes ran from 9.5 to 10.5 inches.

The doctoral researches of Edwin L. Cooper, conducted in the period 1946-1948, included sampling in the same area where creel census operations were conducted. He (1949, p. 100) found that the intensive sport fishery cropped off the fast-growing members of the brook trout population almost as soon as they reached the legal size of 7 inches during their second summer. As a result, a high percentage of each years' catch consisted of fish which had not yet spawned. He also offered evidence which demonstrated that very few three-summer-old brook trout lived to spawn a second time.

THE EXPERIMENTAL REGULATIONS

Early in 1949 Cooper's research, combined with the available creel census data, resulted in a recommendation to the Conservation Commission that the minimum size limit be increased to 10 inches on that portion of the North Branch between Lovells Bridge and the county line; the objective was to increase the numbers of brook trout in the experimental section by allowing a larger number of mature fish to spawn at least once. Only the minimum size limit was changed under terms of a Commission order which took effect for the 1949 trout season. Field checks with an AC shocker were made during the late summer and fall to collect scale samples and obtain density indices.

Before the 1950 trout season opened, an additional 2.3 miles of water immediately downstream were placed under the experimental restrictions. At the insistence of the Lovells Hook and Trigger Club, artificial flies were specified as the only legal lure. The Conservation

Commission clarified and reworded the restrictions. The regulations applying to this experimental water for the period 1950-1953 have been: 10-inch minimum size; 10 trout daily, not more than five of which may be brook trout (or 10 pounds and one trout); only artificial flies permitted.

HOW CHANGES WERE MEASURED

Partial creel census results.—The effect of these more stringent regulations on the fishing has been measured by continued use of the shocker and by a partial creel census operated during the past four seasons. The same schedule of sampling days was followed each year by the same individual, who collected fishing statistics at the same sites. Equal numbers of four 10-hour days each season were spent in the recording of anglers' catches from the restricted water and from the stream sections above and below still under the normal state-wide trout regulations (hereinafter referred to as "normal" water). The sampling schedule included each Saturday, Sunday, and holiday. Midweek days were rotated throughout the season. Only records of completed fishing trips were listed. While these records do not provide knowledge either of total pressure or of total catch, they do furnish valid information on the trends in the fishing, and the relative returns from both types of water since they are generous and equal samples collected in the same manner each year. The pertinent statistics are given in Table 1.

The following general conclusions may be drawn from the creel census summary:

1. Except for 1950, more angling trips were recorded on the restricted water than on the normal water. This observation is interpreted to mean that the North Branch fishermen are using the restricted water, despite the added restrictions, in numbers as large or slightly larger than those who fish the normal stream sections. The latter area downstream, in addition to the less stringent regulations in force, was planted yearly with 6,000 to 7,800 (all fin-clipped) hatchery-reared brook trout of "keeper size."

2. The percentage of successful fishing trips on the restricted water increased regularly each year from 10.4 in 1950 to 23.3 per cent in 1953. The proportion of successful trips on the normal water increased during the 1950-1952 seasons from 43.3 to 51.5 per cent, then dropped back to 49.6 per cent in 1953.

3. The observed catch of brook trout larger than 10 inches from the restricted water also has increased each year since 1950 (from 23 fish in 1950 to 104 fish in 1953). Brown trout also were observed to

TABLE 1. PARTIAL CREEL CENSUS STATISTICS, NORTH BRANCH AU SABLE RIVER, CRAWFORD COUNTY, MICHIGAN, 1950-1953 INCLUSIVE (AVERAGE TOTAL LENGTHS, GIVEN IN INCHES, ARE IN PARENTHESES).

Type of water	Year	Total angler-trips contacted	Total unsuccessful trips	Total hours of fishing	Trout caught: Wild brook	Trout caught: Hatchery brook	Trout caught: Wild brown	Total catch observed	Catch per hour, all trout	Catch per hour, all native trout
Restricted water	1950	404	362	1,055.5	23 (10.2)	......	50 (12.5)	73	0.07	0.07
	1951	530	451	1,605.5	36 (10.3)	......	76 (11.9)	112	0.07	0.07
	1952	574	471	1,747.5	52 (10.4)	......	105 (12.5)	157	0.09	0.09
	1953	537	412	1,658.5	104 (10.3)	......	108 (13.0)	212	0.13	0.13
Normal water	1950	487	276	1,683.5	331	[1]318 (7.7)	97 (9.0)	746	0.44	0.25
	1951	430	232	1,541.0	436	[1]65 (7.5)	184 (8.4)	685	0.44	0.40
	1952	480	233	1,743.0	469	[1]208 (7.7)	166 (8.7)	850	[2]0.49	0.36
	1953	407	205	1,443.0	407 (7.7)	175 (8.3)	163 (9.1)	745	0.52	0.40

[1]Average total length data in these years are for both wild and hatchery trout combined, as measurements were not differentiated on the creel cards.

[2]Includes 7 rainbow trout (average total length 9.4 inches).

increase in the catch from the restricted water, following a similar pattern through 1952 (50 fish in 1950, 105 fish in 1952). The recorded 1953 brown trout catch was only slightly above that for 1952 (108 fish).

Catches of wild brook trout from the normal water ranged from 331 fish in 1950 to 469 fish in 1952, while brown trout creeled varied between 97 in 1950 and 184 in 1951. Anglers' creels were further augmented by hatchery brook trout—from a low of 65 hatchery fish in 1951 to a high of 318 hatchery fish in 1950.

4. Angling quality, as measured either by simple catch per hour or catch per hour per trip, has been best in the normal stream sections each year. This was not unexpected in view of differences in regulations and planting procedure on the two areas. However, angling quality in the restricted water was significantly better in 1953 than in any of the three previous years. Differences between the mean catch per hour per angler indices for 1952 and 1953 were examined by the standard "t" test. A value of $t = 3.5$ indicates that there are about 999 chances in a 1,000 that the indices are significantly different.

5. Because of the difference in minimum size regulations in effect, the average size of the angler-caught brook trout in the restricted water has been consistently about two inches larger than for those caught in the normal water. Brown trout average sizes from the restricted water have exceeded those from the normal stream sections by about three and one-half inches.

The weighted average percentages of the total catches found in the various inch-groups are listed in Table 2. The size range of the brook trout catch in normal water is 7.0-10.9 inches. About 73 per cent of the catch is drawn from the 7.0- to 7.9-inch group; about 95 per cent comes from fish between 7.0 and 8.9 inches long. In the restricted water, the size range of the anglers' take has been from 10.0 to 14.9 inches. Here again a high proportion (89.2 per cent) of the brook trout removed are in the first inch-group above the minimum legal

TABLE 2. WEIGHED AVERAGE PERCENTAGE OF TOTAL CATCH IN VARIOUS INCH-GROUPS, NORMAL AND RESTRICTED WATER, NORTH BRANCH AU SABLE RIVER, 1950-1953

Species	Type of water	7.0-7.9	Average percentage of yearly catch in inch-group 8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-23.9
Brook trout	Normal[1]	73.4	21.8	4.4	0.4	....	....	....	....	....
	Restricted	....	....	....	89.2	9.8	0.5	....	0.5	....
Brown trout	Normal	40.9	24.2	13.6	9.8	4.7	3.6	1.3	1.1	0.8
	Restricted	....	....	....	33.1	24.6	14.1	8.4	6.0	13.8

[1]Hatchery brook trout were included in these tabulations for 1950-1952, as they were not identifiable in the creel census records in those years.

length, while most of the remainder are between 11.0 and 11.9 inches long. This suggests that the fishery for the species on both waters is very intensive and is removing a high proportion of the brook trout in both areas very soon after they reach either the 7- or 10-inch minimum length.

Proportions of the total brown trout catches observed in the various inch-groups differed noticeably. There was no great concentration of fish in the inch-group just above the legal length, and a more even distribution of the catch among the inch-groups was evident.

6. The estimated total weight[1] of the observed catch of wild brown trout from the restricted water consistently exceeded the poundage of brown trout observed in creels from the normal water (Table 3). The poundage of 10-inch and larger wild brook trout from the restricted water has been less than the poundage of 7-inch and larger brook trout from the normal water because of the great disparity in the numerical catch. The difference becomes progressively less each year, and if the 10-inch brook trout continue to increase in numbers, the restricted water may eventually yield as many pounds of brook trout, although not as many fish, as are taken from the normal waters. The 1953 calculations (Table 3) show that the total poundage of all wild trout observed from the restricted water slightly exceeded the total poundage of wild trout in the catches of fishermen contacted on the normal water (139 pounds as compared with 135 pounds), althought numerically the total catches of wild fish were 212 as compared with 570.

It has not been possible to measure the increase in sport furnished by the restricted water. Although success in terms of creelable fish is lower than on normal water, under average fishing conditions more 7.0- to 9.0-inch trout will be played and released in the restricted

[1]Weights were assigned to each fish recorded on the basis of measured length. For brook trout, the length-weight curve for Michigan brook trout, prepared by Edwin L. Cooper (1949, p. 90), was utilized. A length-weight curve for North Branch brown trout (Tody, 1949, p. 17), was available from earlier investigations.

TABLE 3. THE ESTIMATED POUNDAGE OF TROUT TAKEN BY ANGLERS CONTACTED IN THE PARTIAL CREEL CENSUS, RESTRICTED AND NORMAL WATER, NORTH BRANCH AU SABLE, 1950-1953

	Pounds of trout taken by angling, restricted water			Pounds of trout taken by angling, normal water			
Year	Wild brook	Wild brown	Total	Wild brook	Hatchery brook	Wild brown	Total
1950	8.85	35.54	44.39	....	[1]123.14	27.36	150.50
1951	14.76	53.06	67.82	....	[1]92.92	49.69	142.61
1952	22.10	80.08	102.18	....	[1]133.06	51.56	184.62
1953	44.27	94.78	139.05	80.69	42.54	54.03	177.26

[1]Weights given in these years are for wild and hatchery brook trout combined. They were not differentiated on creel cards.

water than will be hooked in the normal stream. As elsewhere, the skillful and the lucky anglers creel the majority of the fish.

Electrofishing indices of population density.—Information on the population left each fall after the fishing season was obtained by electrofishing with an AC shocker (Universal, 60 cycle, 500 watts, 110 volt capacity). Timed collections were made each fall starting with 1948 in the vicinity of the Twin Bridge (located about midway in the restricted water). The numbers of trout caught per hour were used as indices of changes in population density. Although the efficiency of the collecting gear used will vary with weather, water stage and personnel, any marked change in actual population density should be detectable even though the magnitude cannot be determined exactly. The Twin Bridge collections were taken between late September and early November; always with an AC shocker of the capacity described, and always with at least one party member who had made the collections in previous years. The results of the electrofishing operations at Twin Bridge 1948-1953 inclusive are given in Table 4.

The data for September, 1948 show the size composition of the brook trout population remaining at the end of the last season of fishing under a 7-inch minimum size. Only 60 brook trout of 230 collected (27 per cent) in two hours of electrofishing were between 7.0 and 9.9 inches long. Brook trout smaller than 5.0 inches were

TABLE 4. SIZE COMPOSITION OF BROOK TROUT TAKEN WITH AC SHOCKER, TWIN BRIDGE, NORTH BRANCH OF THE AU SABLE, RESTRICTED WATER, WITH CATCH PER HOUR INDICES, 1948-1953. (PERCENTAGE OF TOTAL SAMPLE IN EACH INCH-CLASS IS GIVEN IN PARENTHESES)

Size range in inches	Numbers in inch-group in year: September, 1948	November, 1949	October, 1950	October, 1951	September, 1952	September, 1953
2.0- 2.9	44 (19)	5 (3)	1 (1)	[1]....	[1]....	15 (6)
3.0- 3.9	83 (36)	28 (19)	20 (13)	[1]....	[1]....	88 (36)
4.0- 4.9	8 (3)	21 (13)	44 (27)	[1]....	[1]....	26 (11)
5.0- 5.9	9 (4)	5 (3)	26 (16)	1	10	22 (8)
6.0- 6.9	26 (11)	14 (9)	10 (6)	12	15	24 (10)
7.0- 7.9	52 (23)	36 (23)	21 (13)	29	69	21 (9)
8.0- 8.9	6 (3)	35 (22)	23 (14)	60	46	29 (12)
9.0- 9.9	2 (1)	11 (7)	8 (5)	21	18	15 (6)
10.0-10.9	....	2 (1)	6 (4)	5	8	2 (1)
11.0-11.9	....	....	1 (1)	....	1	3 (1)
12.0-12.9	....	....	....	....	....	....
13.0-13.9	....	....	....	1	......	....
Total collected	230	157	160	129	167	245
Minutes shocked	120	40	44	23	38	35
Fish shocked/hour						
2.0-4.9 inches	68	84	89	....	....	221
5.0 inches up	47	155	130	337	264	199
All sizes	115	236	218	....	....	420

[1]Fish in these inch-groups were present but not recorded in these years.

taken at the rate of 68 fish per hour; those from 5.0 inches to 9.9 inches were found at the rate of 47 fish per hour; all sizes together were captured at a rate of 115 fish per hour.

Evidence that the 10-inch minimum size limit accomplished its purpose almost immediately was obtained in August, 1949. One hour of electrofishing at Twin Bridge yielded 219 brook trout from 4.0 to 9.9 inches, of which 170 were above 7.0 inches in length. Another hour of shocking just below the county line (also in the restricted water but not as good brook trout habitat as at Twin Bridge), produced 29 brook trout of which 20 were in the 7.0- to 9.9-inch size classes. Shocking one hour at Eamon's (a locality not under restrictions in 1949) yielded 33 brook trout, only 10 of which were between 7.0-9.9 inches in length.

The fall sampling for the years 1949 through 1953 demonstrates increases in all sizes of brook trout present, although the population enlargement has not been at a regular rate. Prior to inception of the 10-inch minimum size regulation, the 1948 sample yielded 68 brook trout per hour smaller than 5.0 inches. In September, 1953, an index figure of 221 brook trout per hour was obtained for this category, which is made up almost entirely of young-of-the-year fish.

The catch per hour index for brook trout larger than 5.0 inches in 1948 was 47 fish. In succeeding years these indices increased variably to 155, 130, 337, 264, and 199. The irregularities may or may not represent actual population fluctuations. The differences noted are evidence of an increase of brook trout larger than 5.0 inches of about four times for the Twin Bridge area, following operation of the restrictions. Based on the 1948 and 1953 indices for brook trout smaller than 5.0 inches, fish in this size range increased to slightly more than three times their former numbers.

The electrofishing data were examined to determine changes in the size composition of the fall brook trout populations after application of the restrictions. For convenience. the numbers of fish larger than 5.0 inches were compared with the numbers of fish smaller than 5.0 inches in each year's sample. A significantly greater fraction of 1949 and 1950 samples were larger than 5.0 inches on comparison with the 1948 sample. Adjusted Chi-square values, following the methods outlined by Snedecor (1948, p. 197), yield values of 21.00 and 11.62 with corresponding percentages of confidence of 99.9 and 99.7 respectively. Unfortunately, measurements on brook trout less than 5.0 inches were not recorded in 1951 and 1952. However, by 1953, the proportion of large fish to small fish was approximately the same as in 1948 (Chi-square = 1.52, P = 78 per cent). Apparently the 1949 and

1950 populations differed from 1948 because of the protection afforded the 7.0- to 9.9-inch fish because the potential fingerlings available from the spawning of these fish were not yet present in the stream. By 1953, enough additional spawning had taken place to increase the numbers of fish less than 5.0 inches, and bring the proportion of large fish to small fish back closer to 1948 levels.

The main differences between the Twin Bridge samples of 1948 and 1953 are that the range in total length of the 1953 sample was greater, and both large and small fish were present in greater numbers.

The Twin Bridge sampling was augmented during the 1953 fall season by collections at four additional sites in the restricted water and at five sites in the normal water. A total of 517 brook trout were captured in the restricted water in 142 minutes of shocking, while only 231 brook trout were found in 153 minutes of electrofishing from normal stream section (Table 5).

Ideally, we should have similar series of collections for 1948 from both restricted and normal waters to measure the changes that took place. The 1953 data support the conclusion that there has been a population increase in the restricted water. About 2.4 times as many brook trout (218 per hour) were found in the restricted section as in the normal section (91 per hour). We do not know with certainty if the population level of the normal section has increased or decreased since application of restrictions, as the only measure available for the pre-restricted period is the 1948 fall sample taken when the Twin Bridge area was under normal fiishing regulations. Comparison of the 1948 Twin Bridge sample with the 1953 sample (composed of

TABLE 5. SIZE COMPOSITION OF POST-SEASON BROOK TROUT POPULATIONS, RESTRICTED WATER AND NORMAL WATER, 1953, AS DETERMINED FROM AC SHOCKER COLLECTIONS AT FIVE SITES IN EACH AREA

	Brook trout from	
Size range in inches	Restricted water	Normal water
2.0- 2.9	41	38
3.0- 3.9	200	97
4.0- 4.9	50	30
5.0- 5.9	47	15
6.0- 6.9	52	27
7.0- 7.9	43	20
8.0- 8.9	43	2
9.0- 9.9	31	1
10.0-10.9	7	1
11.0-11.9	8	....
Total collected	517	231
Minutes shocked	142	153
Fish shocked per hour		
2.0-4.9 inches	123	65
5.0 inches up	95	26
All sizes	218	91

collections from five widely despersed areas in the normal water) suggests that brook trout smaller than 5.0 inches were present in about equal numbers in 1948 at Twin Bridge and in 1953 in the normal waters as a whole (1948 sample catch per hour of 2.0- to 4.9-inch fish was 68; 1953 normal water sample catch per hour 2.0- to 4.9-inch fish was 65). The greatest difference between these two samples is in the catch per hour indices for fish larger than 5.0 inches. In 1948, the catch per hour index was 47 fish; in 1953 it was 26 fish. The difference noted is ascribed to a combination of factors including size of sample, differences in habitat, and possible differences in angling pressure on fish larger than 7 inches during 1948 and 1953. The fact that the indices for total brook trout taken differed only by 24 fish per hour, or about 20 per cent, lends some weight to the belief that the 1948 Twin Bridge sample and the 1953 normal water sample were from brook trout populations of the same approximate magnitude.

In this latter assumption is granted, then it is reasonable to compare the 1953 samples from the restricted water with the 1953 samples from the normal water to determine the effects of the restrictions on the residual fall populations. As with the Twin Bridge series of samples, the conclusion is reached that all sizes of brook trout have increased in numbers. As to just how much, the 1953 data probably furnish the best estimate, since the figures tabulated are a composite of good, poor and average sites wthin both restricted and normal stream sections. The Twin Bridge data represent what happened in the better brook trout habitat following changes in the regulations.

For the restricted water as a whole, large fish (over 5.0 inches) have increased about 3.6 times in numbers, while small fish (less than 5.0 inches) have increased about 1.8 times in numbers. In the vicinity of the Twin Bridge, the increase of large fish was approximately 4.2 times; the increase of small fish was on the order of 3.2 times.

AGE COMPOSITION OF ANGLERS' CATCH

In addition to scale collections made during each fall shocking, as many scales as possible were obtained from angler-caught fish in both restricted and normal water areas. Cooper (1951, describes evidence which indicates that brook trout scales provide a true index of the age, and in a later paper (1952) gives the scale-sampling procedure and mounting method).

The age composition of angler-caught fish in both restricted and normal waters is given in Table 6. Age-Group II brook trout dominated the catches in the restricted water (70-97 per cent), while Age-

TABLE 6. AGE COMPOSITION OF ANGLER-CAUGHT BROOK TROUT, RESTRICTED AND NORMAL STREAM SECTIONS, NORTH BRANCH OF AU SABLE, 1950-1953. (SIZE RANGES ARE GIVEN IN INCHES IN PARENTHESES)

Year	Age group	Restricted water[1] Number	Restricted water[1] Percentage of sample in age-group	Normal water Number	Normal water Percentage of sample in age-group
	I	....	....	33 (7.0-8.7)	45
1950	II	36 (9.6-10.5)	97	39 (7.0-9.6)	53
	III	1 (11.5)	3	2 (9.3-9.6)	2
	I	....	....	268 (6.7-8.9)	82
1951	II	35 (9.7-11.0)	74	60 ((7.0-10.1)	18
	III	12 (10.0-11.5)	26	....	....
	I	1 (10.0)	1	264 (6.5-8.8)	76
1952	II	65 (9.7-11.6)	88	80 (7.1-10.2)	23
	III	8 (10.3-14.0)	11	5 (7.6-11.4)	1
	I	....	....	165 (6.8-8.8)	73
1953	II	102 (9.0-11.5)	70	54 (7.4-11.9)	24
	III	42 (8.8-12.2)	29	8 (8.6-11.4)	3
	IV	1 (11.6)	1	....	....

[1]The few fish smaller than 10.0 inches and 7.0 inches which appear in this table were not included in catch totals in other tables. They have been utilized to show age and size distribution here.

Group I fish were found most often (73-82 per cent) in creels from the normal stream sections when the 1950 data are excluded (the 1950 sample was too small numerically and did not include enough fish caught in July and August when many two-summer-old fish ordinarily enter the catch under a 7-inch minimum size limit).

Age-Group III brook trout were few in numbers (3 per cent in the 1950 catch on the restricted water, but have varied since between 11 and 29 per cent. One brook trout with four annuli was found among the 1953 anglers' catch, and one Age-Group I fish was observed in the 1952 catch from the restricted water.

In the normal stream sections Age-Group II brook trout constituted the minor fraction of the catch (18 to 24 per cent) when the 1950 sample is excluded for reasons already given. Age-Group III fish have never exceeded 3 per cent of creeled fish from the normal waters in any year.

GROWTH OF THE BROOK TROUT

The growth of the North Branch brook trout was studied following methods listed by Cooper (1953, p. 152), utilizing his previously-constructed nomograph for calculations of total lengths at the end of various years of life. These calculations are given in Table 7, where average calculated total lengths at various ages from angler- and shocker-caught brook trout are compared for pre- and post-restriction years for the restricted waters. Comparisons also may be made for angler-caught fish between the pre- and post-restriction periods for

TABLE 7. COMPARISON OF CALCULATED TOTAL LENGTHS (IN INCHES, WITH STANDARD ERRORS) FOR ANGLER- AND SHOCKER-CAUGHT BROOK TROUT FROM RESTRICTED AND NORMAL STREAM AREAS BEFORE AND AFTER RESTRICTIONS WERE APPLIED, NORTH BRANCH OF AU SABLE RIVER

				Taken by angling Calculated lengths at end of successive years of life				Taken by AC shocker Calculated lengths at end of successive years of life		
Type of water	Age-group[1]	Period	Number in sample	1 year	2 years	3 years	Number in sample	1 year	2 years	3 years
Restricted water	I	Pre-	....	....	....	....	308	3.68±0.04	....	....
		Post-	1	6.90±0.00	....	....	432	3.98±0.04	....	....
	II	Pre-	30	4.18±0.013	7.73±0.10	....	50	3.44±0.95	6.78±1.37	....
		Post-	202	4.39±0.054	8.27±0.68	....	131	3.55±0.06	6.82±0.07	....
	III	Pre-	1	3.60±0.00	5.80±0.00	9.40±0.00	3	3.33±4.92	5.90±7.37	8.37±4.85
		Post-	62	3.39±0.82	6.74±1.18	9.95±1.41	17	3.31±2.51	6.34±2.54	8.82±2.11
Normal water	I	Pre-	11	4.08±0.13						
		Post-	729	4.06±0.25						
	II	Pre-	43	3.40±1.11	6.63±1.48					
		Post-	194	3.40±0.49	6.92±0.74					
	III	Pre-	3	3.73±2.42	6.63±4.71	9.27±4.38				
		Post-	13	3.24±2.08	6.30±2.96	9.00±3.32				

[1]Two Age-Group IV fish were collected in 1953 from the restricted water, one by angling (calculated lengths were: 2.8, 5.8, 8.3, 11.0) and one by shocking (calculated lengths were: 3.0, 5.4, 7.4, 9.6).

normal and restricted waters, although the numbers involved in all but Age-Group II are few in numbers.

Some scales from fish, taken both by angling and by electric shocker, were available from 1947, as well as for the years 1948 through 1953. For Age-Group I fish, the calculated total length at the annulus represents growth made in the previous calendar year. To obtain the proper grouping so that average growth for I's before and after inception of the restrictions can be assessed, the available data has been grouped 1947-1948-1949 (pre-period in Table 7) and 1950-1951-1952-1953 (post-period in Table 7).

For Age-Groups II and III, the pre-period grouping was 1947-1950 inclusive, while the post-period was 1951-1953 inclusive. Some slight error is introduced here, as calculated growth made during the last year in the 1950 samples is included in the pre-period calculations, rather than in the post-period, where it properly belongs. Under the method of analysis there seems to be no alternative. All groupings of three- and four-summer-old fish were treated in the same manner, however.

Samples obtained by angling from restricted and normal waters indicated only silght differences in calculated total lengths between the two stream areas. Statistical tests (t test) between similar groupings (Age-Group II, restricted water, pre-period *vs.* Age-Group II, normal water, pre-period, etc.) all were non-significant.

Comparison of differences between average calculated lengths of angler-caught fish from normal waters for the pre- and post-periods for all age groups also yielded non-significant t values. The same was true for fly-caught brook trout taken in the restricted water, and also for Age-Groups II and III among shocker-collected brook trout in restricted water.

Age-Group I fish collected by shocker in 1950-1953 exceeded in size by 0.30 inches those of a similar age taken by electrofishing in 1947-1949. This significant difference ($t = 5.30$, $P = 99.9$ per cent) can be explained by the fact that in 1946-1948 (when the calculated growth of the 1947-1949 sample took place) anglers were removing a high precentage of the faster-growing two-summer-old brook trout under the 7-inch minimum legal length then in effect. In 1950-1953, the Age-Group I fish were not available to the anglers because of the 10-inch minimum legal size limit.

Comparison of the average calculated total lengths obtained from fly-caught fish with those taken by shocker suggests that angler-captured brook trout grew slightly faster. This selectivity of fishing in taking the faster-growing fish in each age group has been described by Cooper (1953, p. 156) for Pigeon River brook trout. However, only one comparison among the North Branch samples (Age-Group II, post-period) yielded a statistically significant value when the t test was applied ($t = 2.12$, $P = 96.5$ per cent). It is believed that this significant difference resulted from the removal by angling of a high percentage of the available Age-Group II brook trout in the restricted water.

No pronounced differences were found between pre- and post-retriction average calculated lengths which cannot be explained, either among fly-caught or shocker-collected samples. It is concluded that the rate of growth has not changed since inception of the restriction in 1949, even though the brook trout population is now about two and one-half times larger than in 1948.

POSSIBLE EFFECTS OF STREAM IMPROVEMENT

It is likely that the stream improvement, performed in 1949 and 1950, had a beneficial effect on the brook trout environment. This might have affected the results of the experiment. The improvements consisted of deepening and narrowing about one and one-half miles at the upper end of the restricted water, and about one-half mile of stream in the normal water. Wide, shallow, weed-filled inactive portions of the stream were filled in by drag-line and bulldozer using bottom materials removed in deepening the main channel. Maximum depths were increased from 2 to 3 feet to 5-7 feet, and in places the channel width was decreased from 100 feet to 40 feet or less. Cover in the form of logs and stumps was anchored in these channels.

The speeding of the current and the narrowing of the stream bed may have lowered water temperatures. Greater average depth, faster current and bottom type alteration doubtless changed the nature of the food supply. However, these two factors are not believed to have been limiting on the size of brook trout populations in the sections of the North Branch included in this study. Although water temperatures in the mid-seventies are common in much of this part of the stream following peak summer air temperatures, there are many spring-fed areas to which brook trout retreat during such critical periods. As concerns effects on the food supply, the North Branch has always rated at the top of the list of Michigan streams which have been studied. There is no reason to believe that narrowing and deepening the channel would have caused any marked increase in bottom food organisms.

The channel deepening may have increased the survival of brook trout by creating better and more escape cover in the form of deeper holes and runs, and may have aided in the population increases described. Earlier Michigan studies noted (D. S. Shetter and A. S. Hazzard, 1939, p. 295; D. S. Shetter and J. W. Leonard, 1943, p. 41) that deeper water usually contained more and/or larger trout. However, it should be noted that none of this type of improvement work was done immediately upstream from the Twin Bridge in the restricted water where the population studies have been made each year (Table 4).

If channel improvement was a factor in the population increase among brook trout of the restricted water, why did it not operate similarly in the normal water? Numerous successful fishing trips were recorded in the channel-improved portions of the restricted water, but very few successful anglers were seen by the census clerk along the improved channel in the normal water. Although the arguments concerning the effect of the stream improvement are weak and are not supported by any data, the possibility is not excluded that a portion of the increases noted in the anglers' catches stems from increased survival brought about by stream improvement done coincident with regulation changes.

Summing up all arguments, two factors are mainly responsible for the brook trout population increase in the restricted water and the progressive enlargement in the total catch of the species there. These are:

1. Protection of a high proportion of fish to a size which permits them to spawn at least once. The increased spawning has led to an increase of fingerlings present in the restricted stream areas; and,
2. Elimination of considerable hooking mortality among fish less than the minimum legal length by utlizing a "flies only" regulation.

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DISCUSSION

DISCUSSION LEADER CALHOUN: I would like to bring out a point which I think is very important in this work. What about the number of trout that are caught and released by anglers in the test section? Did you get any data on that?

DR. SHETTER: That point is one that Ed Cooper and a number of us have kicked around for years, as to whether you can ever get any valid information on how many undersized fish an angler hooks and releases. We did not attempt to collect such information on the North Branch. Perhaps we made a mistake in so doing. You have to take the angler's word for what he puts back. We know, for instance, that some of them give you a pretty good answer, but with others, you know—just from the standpoint of time—they could not possibly have handled as many fish as they claimed. Does that clarify anything?

I will say this, that the one thing we could not measure on the North Branch was the tremendous increase in sport that we did provide the anglers under this type of legislation.

At the risk of being criticized for introducing my own data on the thing, at the end of the season Dr. Hazzard and I and another angler (who is a "doubting Thomas" about the whole deal) visited the North Branch for an afternoon. We fished about three hours, and between us handled 60 fish from 6 to 9½ inches, in addition to which this other fellow took one legal 10-inch fish.

I have personally duplicated that type of fishing any number of times, and so have many of the people who fish the stream, and it is one reason why it has become popular, at least with a fair number of the North Branch anglers.

MR. CALHOUN: I think that is one of the most significant parts of this regulation. We are having our cake and eating it, too, and large numbers of people are going to the Au Sable for the pleasure of catching and releasing fish under 10 inches—probably catching more large fish and releasing them than they would have under other regulations.

MR. WALTER HAUPT (Daniel Boone Hunters League, Milwaukee, Wisconsin): Does the state of Michigan plant legal sized trout?

DR. SHETTER: The state of Michigan does plant legal sized trout, but perhaps I did not make it clear that there were no trout planted in this restricted water. In this experimental 10-inch water, no trout were planted during the experiment.

Immediately below it, the brook and rainbow trout which were stocked were marked by a distinctive fin clip, so that any that might have come upstream could be determined in the catch. I might add, however, that we never did find any moving upstream in the catch of the 10-inch water.

MR. HAUPT: Does Michigan have a fall planting or a spring planting?

DR. SHETTER: Well, they make various plantings, depending on whether it is done in lakes or streams. Most of the planting is done during spring, and during the trout season.

MR. HAUPT: Is your Au Sable River close to the population of Michigan?

DR. SHETTER: It is relatively close. The north branch, at the mouth, anyway, is not over 200 miles by good highways from Detroit, and much closer to Flint and Bay City, by about a hundred miles.

STUDIES ON THE POPULATION OF LEGAL-SIZE FISH IN WHITMORE LAKE, WASHTENAW AND LIVINGSTON COUNTIES, MICHIGAN

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An estimate of the population of legal-size game fish in Whitmore Lake was made during the spring of 1953 using a commercial type of trap net (described by Cooper and Latta, 1954) for collecting fish, and using the Schumacher and Eschmeyer (1943) and Schnabel (1938) formulas in the mark-and-recapture procedure of estimating population size. The extensive net collections also provided data for analyses of age and growth, total mortality rate, distribution of fish within the lake, and adequacy of sample size in connection with growth studies.

Whitmore is one of a dozen lakes which have been under intensive study during the past eight years for an evaluation of the effect of liberalized fishing regulations (Christensen, 1953). An intensive creel census is conducted on these lakes to determine the annual yield to anglers, and trap-net population estimates on certain of the lakes are being made to determine what the lakes contain in the way of legal-size fish for a comparison with angler yields. Thus far, trap-net population estimates have been made on Sugarloaf Lake (five consecutive years), Fife Lake (one year), Big Portage Lake (one year), and Whitmore Lake (one year—present study).

On Whitmore Lake six trap nets were fished for 33 consecutive days during the Spring of 1953. This netting provided the primary basis for the fish population estimates. In the case of the largemouth bass, the population was also estimated from records on marked (fish captured in the trap nets and marked) and unmarked fish captured by anglers on the opening week end of the bass fishing season in June. The records of fish caught by trap nets were also analyzed in terms of catch per unit of netting effort for different intervals of the netting period, for different depths of water, and for four geographic divisions of the lake. The purposes of this detailed analysis of trap-netting records were (1) to obtain a general understanding of the distribution of legal-size fish within the lake, and (2) to investigate the possibility of using trap-net catch records, on a per-unit-of-effort basis, as indices to population density.

In the present study of Whitmore Lake, large series of scale samples were taken at random from trap-netted fish for a study of age and growth and for the computation of total annual mortality rates.

ACKNOWLEDGMENTS

Assistance in the field netting party was provided by Michigan prison inmates. Mr. C. A. Pfitzmaier, a department employee, also gave some assistance on the field party. Messrs. R. W. Phillips and J. E. Williams made age determinations on the fish scale samples. Mr. K. G. Fukano verified many of the statistical calculations. For the opening week-end bass census, field help was given by Dr. F. F. Hooper and Messrs. H. D. Tait, R. O. Anderson and Mr. Phillips. Dr. Hooper supplied certain morphometric data for the lake. Mr. K. E. Christensen generously supplied unpublished data on the 1952 and 1953 creel census on Whitmore Lake. Dr. A. S. Hazzard offered many valuable suggestions.

DESCRIPTION OF WHITMORE LAKE

A morphometric map of the lake was prepared by a field party from the Institute for Fisheries Research in January, 1940, and that field map is the basis for available data on physical features. The shore line and depth contours are shown in Figure 1. The lake is 677 acres in area. It is generally oval in shape. Its greatest length is about 1½ miles. The maximum depth is 69 feet, and deep water in the lake (*i.e.*, over 25 feet) is largely confined to the northern half. Data on distribution of lake-bottom area in relation to depth contours are included in Table 1.

Bottom soils in the lake are largely sand, gravel, and organic muck. There are some extensive areas of rubble and boulder bottom, especially on shoal areas off points, in water less than two feet deep. Submerged aquatic vegetation is abundant during summer months over about one-half of the lake area, at depths of less than 25 feet.

FISH POPULATION OF THE LAKE

Whitmore Lake has a population of warm-water game and coarse fishes which is quite typical of lakes of southern Michigan. The bluegill (*Lepomis macrochirus*) is by far the predominant fish in the lake, among species which exceed a length of six inches. Other abundant species include the pumpkinseed (*Lepomis gibbosus*), black crappie (*Pomoxis nigromaculatus*), rock bass (*Ambloplites rupestris*), largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), yellow bullhead (*Ameiurus natalis*), brown bullhead (*Ameiurus nebulosus*), bowfin (*Amia calva*), and lake chubsucker (*Erimyzon sucetta*). Less abundant species include the smallmouth bass (*Micropterus dolomieu*), warmouth (*Chaenombryttus coronarius*), white sucker (*Catostomus commersoni*), grass pickerel

(*Esox vermiculatus*), carp (*Cyprinus carpio*), redhorse (*Moxostoma* sp.), and golden shiner (*Notemigonus crysoleucas*).

Trautman (1941) kept extensive records of angling on Whitmore Lake done by himself and friends during the five-year period 1934-1938 and made observations on fish reproduction and survival of young fish. He concluded that there were important differences in survival of young from different year classes, and that these differences were reflected in the size distribution and numerical abundance of legal-size fish caught in subsequent years. The four species recorded by Trautman in his creel records (bluegill, largemouth bass, yellow and brown bullheads) were likewise the four most abundant species found to be present in 1953, and the 1953 studies have shown a dominance of year classes similar to that reported by Trautman.

Christensen (1953) recorded the fishing intensity on Whitmore Lake for the years 1946-1950 as 22 to 101 thousand angling hours per year, the total catch as 18 to 96 thousand fish per year, and the average catch per hour as 0.7 to 1.0. Percentage composition of anglers' creels for selected species was: 43 to 71 per cent bluegills, 10 to 25 per cent yellow perch, 1.6 to 4.2 per cent largemouth bass, and 1.0 to 3.5 per cent bullheads.

PROCEDURE

A randomized schedule of trap-netting stations was developed by recourse to the table of "ten thousand randomly assorted digits" in Snedecor (1946). Use was made of a copy of the Institute map of Whitmore Lake on which the lake outline encompassed a map area of 345 square inches. This map was superimposed over a grid in which the individual squares were 1½ by 1½ inches and in which the grid squares were numbered 1 to 330, in sequence. Snedecor's table was used (by one of the procedures recommended by that author) to select a series of three-digit numbers (001 to 999), and such of these numbers which were contained within the outline of the lake (while superimposed over the grid) were reassigned, in sequence, to become netting station numbers 1 to 236.

It was apparent at the start that the 5-foot commercial trap nets could not be fished effectively in water much less than three feet in depth, and it was regarded as impractical to attempt to fish these trap nets in water over 30 to 35 feet in depth. With respect to very shallow water, it was anticipated that fish of legal size (generally over 6 inches) would not be regularly present in shallow water near shore, except as they would migrate into the shallow water for feeding at night. The minimum depth at which the trap nets were fished was about 3 feet, and those netting stations which were located at depths of less than 3 feet were fished by a wire funnel pot. These wire pots were far less effective in catching fish than were the trap nets. The distribution of the netting stations over the lake as a whole was designed to give uniform coverage according to lake area, and the fact that the wire pots caught few fish means that uniform netting coverage did not include the shoreline shoals of depth less than 3 feet. Direct observations indicated that larger fish were not present on these shoals during the daytime. Fish moving onto the shoals presumably at night were, however, subject to capture by trap nets set in somewhat deeper water.

At depths greater than 30 to 35 feet the stations were fished by experimental gill nets, each net being 125 feet by 6 feet and made up of five experimental sections of the following mesh sizes: 1½, 2, 2½, 3 and 4 inches, stretched measure. The gill nets in deep water caught far fewer fish per net-day than did the trap nets, due in part to differences in effectiveness of gear and due no doubt in large part to a much lower concentration of fish in the very deep water. Since only 10 per cent of the lake area is over 35 feet in depth, the lesser efficiency of gill nets in the very deep water was of minor significance in the netting effort on the lake as a whole.

The present system of employing random numbers for the selection of netting sites on the lake proved to be very effective in obtaining uniform netting coverage throughout the lake, from the point of view of both geographical distribution and depth of water. This fact is illustrated by a comparison of the percentage of all net sets made in a particular geographical "quarter" (Fig. 1) of the lake, with the percentage of lake area contained within the same "quarter"; and by a similar comparison of percentages of net sets and lake areas within various depth contours (Table 1). For examples: 25 per cent of the 236 stations were located in the northwest "quarter" of the lake, and this part of the lake has 28 per cent of the total area; and 22 per cent of the 236 stations were between the 5- and 10-foot depth contours, and this part of the lake has 24 per cent of the area.

The 236 netting sites selected by random numbers are located on Figure 1. Whereas the number of stations selected for netting was 236, fishing with wire pots in very shallow water was so ineffective that 13 of the 43 wire-pot stations were dropped from the netting schedule. This reduced the netting stations from 236 to 223. At each netting station, a single net (either trap, wire pot, or gill net) was fished for one night only. In the selection of netting locations, by the grid system as described above, a considerable number of locations on the lake were repeat stations where from two to six net-station num-

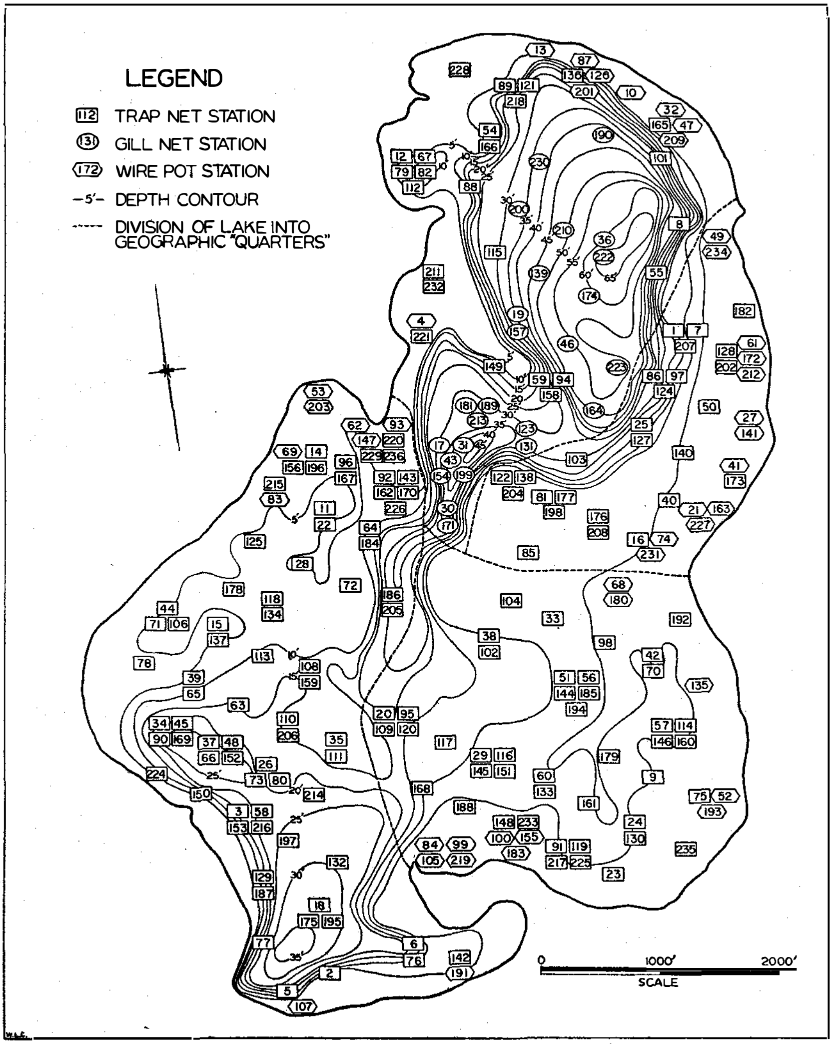

Fig. 1. Map of Whitmore Lake showing depth contours, division of the lake into geographic "quarters," and the locations of 236 randomly selected netting stations.

bers fell on the same point. At these locations a net was fished from two to six times. A total of six commercial trap nets, two wire pots, and two experimental gill nets were used, with from six to 10 nets in operation at a time, to fish through 223 stations in 33 days. With minor exceptions the 223 stations were fished in numerical sequence.

The netting party on the lake located each netting site by general orientation with shoreline features, and to a lesser degree by actual depth soundings. Thus the actual depths and locations at which the nets were fished were not always precisely those indicated on the map (Fig. 1). However. in the analysis of catch records by depths, results from numerous stations are combined into averages, so that minor errors in individual depth records should be compensatory.

The compass direction in which each net was set was varied on a systematic pattern, with the net at Station No. 1 fishing north, No. 2 fishing east, No. 3 south, No. 4 west, No. 5 north, and so forth. This was done in order to eliminate possible bias in collecting fishes of different species, or fishes of different sizes, assuming that a species or size difference might be related to the movements of fish and therefore to the probability of capture by nets.

All fish captured by nets were marked by fin clipping for later identification, scale samples and length measurements were taken, and the fish were liberated at the point of capture. Each net was then moved to a new location. Scale samples and individual length measurements were taken on all fish when first captured, but not on fish when captured a second time. Scale samples were taken on all bluegills in the first two trap-net lifts each day throughout the netting period; for all other scaled species, samples were taken from practically all fish.

Catch records were recorded daily, by netting station number, and

TABLE 1. DISTRIBUTION, BY GEOGRAPHIC AREA AND BY WATER DEPTH, OF 236 NETTING STATIONS ON WHITMORE LAKE, SELECTED BY RECOURSE TO RANDOM NUMBERS

Lake divisions: Geographical and contour interval in feet	Number of stations fished by					Lake area within divisions	
	Trap nets	Gill nets	Wire pots	All nets Number	All nets Per cent	Acres	Per cent
NW ¼	25	25	9	59	25	190	28
NE ¼	26	....	13	39	16	88	13
SW ¼	73	....	9	82	35	230	34
SE ¼	44	....	12	56	24	169	25
Total	168	25	[1]43	236	100	677	100
0-5	48	....	[1]43	91	39	240	35
5-10	52	....	....	52	22	161	24
10-15	22	....	....	22	9	59	9
15-20	16	....	....	16	7	42	6
20-25	13	....	....	13	5	35	5
25-30	12	....	....	12	5	45	7
30-35	5	....	....	....	....	....	....
30-40	....	10	....	15	6	39	6
40-50	....	7	....	7	3	22	3
50-60	....	6	....	6	3	27	4
60-69	....	2	....	2	1	7	1
Total	168	25	[1]43	236	100	677	100

[1]Of the 43 wire-pot stations, only 30 were fished; these 30 sets caught practically nothing, so that there was little point in making the remaining 13 sets.

separately for "legal-size" fish as contrasted with fish of "sub-legal" size. Legal-size fish include bass over 10 inches, pike, gar and bowfin over 14 inches, and all other fish over 6 inches. Whereas the 6-inch limit on pan fish has been dropped as a state-wide regulation, the legal and sub-legal categories are here retained as a means of separating the larger fish (those prized by anglers) from the smaller ones.

During the 33 days of netting, periodic examinations were made of the shoreline of Whitmore Lake to check on the presence of dead fish, since the netting and marking of fish might be expected to cause some mortality, and since the daily allowance for any mortality of marked fish is an essential part of the method used in the population estimate. Daily mortality records were kept on any marked and unmarked fish encountered. The extent of this mortality was low, due no doubt to cool water temperatures (44° to 64° F.) prevailing during the period. The greatest mortality occurred during the first week in May, and a careful inspection of the entire shoreline on May 9 resulted in the recovery of 110 dead fish; of these, 26 were fish which had been captured by trap nets and marked by fin-clipping, while 84 were unmarked fish, *i.e.*, fish which had not been previously caught in our trap nets and for which the mortality could not be attributed to netting. During the entire netting period only 34 dead marked fish were found out of a total of 7,373 which were marked and released.

The estimate of the population of fish is based on the total catch of fish in trap nets, gill nets, and wire pots. Certain of the analyses on the catch per unit of netting effort are based on only the catch of the trap nets, because the numbers of fish taken by gill nets and wire pots were too few to allow significant statistical treatment. The unit of catch-effort analysis is the catch by one net in each overnight set; in each instance the time interval amounted to approximately 24 hours, with some variation depending upon the particular daylight hour on which the net was set and the particular hour on which it was lifted. The small variation in length in hours of the net sets is judged to be of very minor importance, especially for nets set in relatively shallow water (less than 15 or 20 feet), because it is believed that the nets caught almost all of their fish during hours of darkness.

For the detailed analysis of netting records, one basis was by dividing the lake into northwest, northeast, southwest, and southeast geographic areas (approximately into quarters); another basis was the division of the lake into 5-foot contour intervals (0′-5′, 5′-10′, etc.) according to the water depth at the netting station; and the third basis was by dividing the 33-day netting period into three sub-periods: April 17-27, April 28-May 8, and May 9-19.

POPULATION ESTIMATES

The netting on Whitmore Lake took 7,928 fish (7,419 initial captures plus 509 recaptures) of 18 species. Of the 7,928 fish, 6,187 were legal-size game fish, pan fish and bullheads; 1,538 were sub-legal pan fish; and 203 were suckers, bowfin, carp, and other coarse fishes. The trap nets took 7,859 fish (99 per cent of the total); gill nets took 41 fish; and wire pots, 28. Of the 7,419 fish initially caught, 7,373 were fin-clipped and released.

The numbers of fish caught, marked, and recaptured, and the population estimates and their confidence limits computed by the Schumacher and Eschmeyer formula are listed for certain species in Table 2. Species for which the numbers marked and recaptured were inadequate for a population estimate were as follows:

	Caught	Marked	Recaptured
Warmouth	20	20	0
Yellow perch	10	10	0
Grass pickerel	3	3	0
Chubsucker	71	71	0
Smallmouth bass	2	2	0
Redhorse sp.	5	5	1
Carp	8	8	0
Golden shiner	1	1	0

The estimates on sub-legal fish (in Table 2) are small as compared to estimates for legal-sized fish, because the sublegal groups include a very lmited size range of fish, due in turn to the fact that the nets did not catch fish much smaller than legal size. In other words, the present population estimates involve primarily only the legal-size fish. Population estimates, based on the Schnabel formula, were very similar to the Schumacher and Eschmeyer estimates recorded here.

The bluegill population estimate for the Spring of 1953 was 28,692; the brown bullhead was second in abundance, with 15,916; and the largemouth bass third, with 4,532. Total population of legal-size game and pan fish, exclusive of rare species, was 54,491. This amounted to 80 fish per acre (Table 3).

Whereas the trap net estimate of legal-size largemouth bass was 4,532 fish, the independent estimate of legal-size largemouth bass, based on angler returns during the opening week-end (June 20 and 21) of the bass season, was 3,397 fish. This latter estimate was based on 123 angler-caught bass of which 47 were fish which had been marked during the trap netting four to eight weeks earlier; and on the assumption that the 1,204 marked legal-size bass (plus the 94 bass which were slightly under legal size, but which should have attained legal size by June 20) which were liberated in the lake during April and

TABLE 2. NUMBERS OF FISH CAUGHT, MARKED AND RELEASED, AND RECAPTURED, AND POPULATION ESTIMATES (WITH CONFIDENCE LIMITS) COMPUTED BY THE SCHUMACHER AND ESCHMEYER FORMULA

Species and size	Total[1] catch	Marked and Released	Recaptures	Schumacher and Eschmeyer estimates: Population	± one standard error: Lower limit	± one standard error: Upper limit
Bluegill						
Legal size (6″+)	3,036	2,886	145	28,692	25,674	31,710
Sub-legal (4½-6″)	1,271	1,238	29	26,624	20,149	33,099
Largemouth bass						
Legal size (10″+)	1,381	1,204	176	4,532	4,079	4,985
Sub-legal (7½-10″)	138	135	3	3,921	1,688	6,154
Black crappie						
Legal size (6″+)	246	203	42	567	505	629
Sub-legal (5½-6″)	17	15	1	....	....	....
Pumpkinseed						
Legal size (6″+)	72	56	0	[2]1,274	914	1,634
Sub-legal (4½-6″)	82	78	3	1,451	1,040	1,862
Rock bass						
Legal size (6″+)	140	127	13	713	541	885
Sub-legal (5-6″)	23	23	0	....	....	....
Northern pike (14″+)	84	73	5	539	445	633
Yellow bullhead (6″+)	598	529	69	2,258	2,025	2,491
Brown bullhead (6″+)	605	592	12	15,916	12,816	19,016
Bowfin (14″+)	56	50	4	324	227	421
White sucker (8″+)	59	44	6	199	127	271

[1]Includes recaptures.
[2]Estimate for pumpkinseeds based on all fish, subdivided by size according to ratio in total catch.

May were still present on June 20 to 21 (there was no legal bass fishing in the lake prior to June 20). The estimate from angler-caught bass is 2.5 units of standard error below the trap-net estimate, which strongly suggests there is some unrecognized source of bias in either, or both, of the methods. An average of the trap-net and angler-record estimates would put the population of legal-size largemouth bass at about 4,000.

Fish netted on Whitmore Lake were not weighed. However, a large

TABLE 3. POPULATION ESTIMATE AND TOTAL ANGLER HARVEST OF LEGAL-SIZE FISH OF PRINCIPAL GAME AND PAN FISH SPECIES[1] IN WHITMORE LAKE

Species	Population estimate, Spring, 1953: Total number	Per Acre: Number	Per Acre: Pounds	Angler harvest: 1952	Angler harvest: [2]1953
Bluegill	28,692	42.38	9.91	13,818	38,405
Largemouth bass	4,532	6.69	8.09	707	2,831
Black crappie	567	0.84	0.34	430	922
Pumpkinseed	1,274	1.88	0.57	1,599	4,265
Rock bass	713	1.05	0.30	462	581
Northern pike	539	0.80	2.25	502	344
Yellow bullhead	2,258	3.34	1.64	127 (both bullheads)	464 (both bullheads)
Brown bullhead	15,916	23.15	12.19		
Total	54,491	80.49	35.29	17,645	52,934

[1]Yellow perch not included, because a population estimate was not possible.
[2]Not including data for the winter of 1953-1954.

and random series of each species was measured for total length (Tables 4 to 8), and using these length frequencies of legal-size fish, average weights were computed from length-weight data given by Beckman (1946) for the bluegill, largemouth bass, pumpkinseed, rock bass, and northern pike, and similar data recorded by Carlander (1950) for the black crappie, yellow bullhead, and brown bullhead. Average weights were applied to the population estimates for individual species to give total weights—which are given on a per-acre basis in Table 3. Total weight of legal-size game and pan fish was 35 pounds per acre, made up largely by the brown bullhead, bluegill and largemouth bass.

The claim is sometimes made that large fish in a lake become too smart to be caught by anglers, and that anglers therefore catch off only the smaller fish. The present records on largemouth bass throw some light on this question. The 1,204 marked legal size bass in the lake at the end of the netting period on May 19 had an average length of 13.29±0.06 inches while the 47 marked bass found in anglers' creels on June 20-21 had an average length of 13.55±0.26 inches; the dif-

TABLE 4. LENGTH- AND AGE-FREQUENCY DISTRIBUTIONS OF 1,877 BLUEGILLS FROM WHITMORE LAKE, SPRING OF 1953

[1]Total length, inches	Age in completed winters							
	III	IV	V	VI	VII	VIII	IX	X
4.2-4.3	1							
4.4-4.5	1							
4.6-4.7	3	1						
4.8-4.9	3	7						
5.0-5.1	..	16						
5.2-5.3	1	62						
5.4-5.5	..	90						
5.6-5.7	1	162						
5.8-5.9		182						
6.0-6.1		228						
6.2-6.3		215						
6.4-6.5		220	1					
6.6-6.7		190	1					
6.8-6.9		106	2					
7.0-7.1		109	5					
7.2-7.3		63	5					
7.4-7.5		25	7	1				
7.6-7.7		17	8	1				
7.8-7.9		5	8	2				
8.0-8.1			4	5				
8.2-8.3			4	12	1	1		
8.4-8.5			3	9	12	1		
8.6-8.7				8	6	10	1	
8.8-8.9				5	5	8	7	
9.0-9.1				2	2	5	3	1
9.2-9.3					2	2	4	1
9.4-9.5						1	1	
9.6-9.7							1	
9.8-9.9							1	
Total	10	1,698	48	45	28	28	18	2
Mean length	4.83	6.26	7.61	8.39	8.65	8.83	9.12	9.15

[1]All lengths of fish were measured to the nearest 0.1 inch; and mean lengths were computed from the original measurements, i.e., not from length-group midpoints.

TABLE 5. LENGTH- AND AGE-FREQUENCY DISTRIBUTIONS OF 1,293 LARGEMOUTH BASS FROM WHITMORE LAKE, SPRING OF 1953

[1]Total length in inches	Age in completed winters													
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
6.0-6.4	1													
6.5-6.9	..													
7.0-7.4	1													
7.5-7.9		4												
8.0-8.4		6	1											
8.5-8.9		25	1											
9.0-9.4		41	3											
9.5-9.9		43	6	1										
10.0-10.4		31	10	..										
10.5-10.9		16	54	1										
11.0-11.4		1	97	2										
11.5-11.9			95	11										
12.0-12.4			119	26	3									
12.5-12.9			55	74	7									
13.0-13.4			17	82	7	1								
13.5-13.9			10	59	14	4								
14.0-14.4			..	18	41	18	2							
14.5-14.9			..	7	31	16	2							
15.0-15.4			1	3	22	22	11	1						
15.5-15.9				..	10	14	4	..						
16.0-16.4				1	3	20	8	..	1					
16.5-16.9					1	12	10	5	..					
17.0-17.4						5	10	4	2	1				
17.5-17.9							6	8	3	2	..			
18.0-18.4							3	6	2	1	..	..		
18.5-18.9							1	6	1	..	..	..	..	
19.0-19.4							1	4	1	3	..	..	..	..
19.5-19.9									..	1	..	1	..	1
20.0-20.4									1	2	..	..	1	2
20.5-20.9											..	..	..	..
21.0-21.4											1	..	..	..
Number	2	167	469	285	139	112	58	34	11	10	1	1	1	3
Mean length	6.60	9.54	11.73	13.12	14.41	15.39	16.46	17.86	18.03	18.81	21.0	19.5	20.0	19.93

[1]All lengths of fish were measured to the nearest 0.1 inch; and mean lengths were computed from the original measurements.

TABLE 6. LENGTH- AND AGE-FREQUENCY DISTRIBUTIONS OF 216 BLACK CRAPPIES, AND LENGTH-FREQUENCY DISTRIBUTIONS OF YELLOW AND BROWN BULLHEADS, FROM WHITMORE LAKE, SPRING OF 1953

Total length, inches	Black crappie					Yellow bullhead	Brown bullhead
	Age in completed winters						
	II	III	IV	V	VI		
4.9-5.1	2						
5.2-5.4	4						
5.5-5.7	4						
5.8-6.0	5					1	1
6.1-6.3	4					..	..
6.4-6.6	3					1	3
6.7-6.9	2					1	2
7.0-7.2	1					4	4
7.3-7.5	1	2				4	4
7.6-7.8		6				11	3
7.9-8.1		16				32	2
8.2-8.4		25				21	9
8.5-8.7		31				43	11
8.8-9.0		41				61	29
9.1-9.3		28				57	33
9.4-9.6		16				51	77
9.7-9.9		7	1			38	76
10.0-10.2		5	..			59	101
10.3-10.5		1	..			37	82
10.6-10.8		1	1			41	61
10.9-11.1			1			25	39
11.2-11.4			1	1		12	17
11.5-11.7				..		10	19
11.8-12.0				..		7	10
12.1-12.3				3		3	8
12.4-12.6				..	1	3	..
12.7-12.9				1	1	..	..
13.0-13.2						4	2
Total	26	179	4	5	2	526	593
Mean length	5.98	8.81	10.7	12.2	12.6	9.6	10.0

ference is not statistically significant. The percentage distributions of the two groups of fish by length groups were:

	10-11.9″	12-13.9″	14-15.9″	16-17.9″	18-19.9″	20-21.9″
47 angler-caught bass:	19	43	32	4	2	..
1,204 marked bass present:	27	40	20	9	3	1

The present data do not support the claim that big bass are too smart for the angler.

Age determinations from scales were made on 3,914 fish—1,877 bluegills, 1,293 largemouth bass, 216 black crappies, 148 pumpkinseeds, 147 rock bass, 80 northern pike, and 153 of other species. The age and growth analyses are summarized in Tables 4 to 8. The few scale samples which were unreadable because of scale regenerations are not included in these tables. Age determinations were not attempted on the bullheads. Growth of game fishes in Whitmore Lake is about the same as Michigan state-wide averages (*cf.* Beckman, 1949).

One of the main purposes of the present study was to compute the annual mortality rates for game species from age-frequency distributions of scale-sampled fish, and to resolve total annual mortality into

TABLE 7. LENGTH- AND AGE-FREQUENCY DISTRIBUTIONS OF 148 PUMPKINSEEDS AND 147 ROCK BASS FROM WHITMORE LAKE, SPRING OF 1953

Total length, inches	Age in completed winters								
	Rock bass					Pumpkinseed			
	III	IV	V	VI	[1]VII, VIII, IX, X	IV	V	VI	VII
4.2-4.3						4			
4.4-4.5	2					7			
4.6-4.7	..					12			
4.8-4.9	..					13			
5.0-5.1	3					13			
5.2-5.3	3	1				9			
5.4-5.5	2	6				9			
5.6-5.7		2				2	1		
5.8-5.9		2				8	..		
6.0-6.1		10				3	1		
6.2-6.3		15				5	2		
6.4-6.5		14	1			7	..	2	
6.6-6.7		16	..			3	1	2	
6.8-6.9		12	..			1	2	2	
7.0-7.1		19	..			3	4	4	
7.2-7.3		13	3				..	5	
7.4-7.5		5	..				1	4	
7.6-7.7		4	1				3	6	
7.8-7.9		..	1					5	1
8.0-8.1		1	..					..	1
8.2-8.3		1	1					1	
8.4-8.5			1					1	
8.6-8.7				2					
8.8-8.9									
9.0-9.1					1				
9.2-9.3					1				
9.4-9.5					1				
9.6-9.7				1	1				
9.8-9.9					1				
Total	10	121	8	3	1,1,2,1	99	15	32	2
Mean length	5.05	6.67	7.55	8.97	9.1-9.7	5.34	6.87	7.38	7.95

[1]Individual length records on older rock bass: VII, 9.1; VIII, 9.2; IX, 9.5, 9.9; X, 9.7.

TABLE 8. AVERAGE TOTAL LENGTH IN INCHES (UPPER FIGURE) BY AGE GROUPS AND AGE-FREQUENCY DISTRIBUTIONS (LOWER FIGURE) OF MISCELLANEOUS SPECIES FROM WHITMORE LAKE, SPRING OF 1953

Age in completed winters	Warmouth	Northern pike	Yellow perch	[1]Bowfin	Mud pickerel	White sucker	Chub sucker	Smallmouth bass	Redhorse sp.	Carp
I	....	15.7	....	....	....	....				
	....	6	....	....	....	....				
II	....	21.6	....	....	....	....				
	....	19	....	....	....	....				
III	....	24.2	5.5	18.7	....	....	7.09			19.8
	....	45	1	18	....	....	17			5
IV	5.66	26.4	8.04	22.3	12.1	11.9	8.52	10.9		26.4
	8	4	5	12	3	8	13	1		1
V	6.39	26.4	8.93	24.9	....	17.1	9.12	16.7	15.0	
	8	3	3	3	....	11	5	1	1	
VI	7.17	26.7	9.3	23.9	....	17.9	9.55			
	3	2	1	5	....	4	2			
VII	....	24.8	....	25.5	....	18.4			17.2	
	....	1	....	1	....	12			1	
VIII	6.7	....	....	....	....	....				
	1	....	....	....	....	....				
Number of fish	20	80	10	39	3	35	37	2	1	6

[1]Age determinations on bowfin, from scale examinations, are tentative.

angling mortality rate (from available creel census data) and natural mortality rate. Total mortality rate is the complement of survival rate which is computed from the formula of Ricker (1945):

$$\text{s (survival)} = \frac{\ldots + \text{III} + \text{IV} + \text{V} + \ldots}{\ldots + \text{II} + \text{III} + \text{IV} + \ldots}$$

in which the numbers of fish in particular age groups are substituted for the corresponding year groups. The formula, when applied over the span of age groups represented among the data, gives a survival rate which is weighted according to numbers of fish. Use of the formula is based on the assumption that the age-frequency distribution of the samples is representative of the fish population in the lake both at the time of sampling and over a period of years. If a particular year class is unusually abundant, age-frequency data are needed over the period during which the abundant year class runs its course. The present data for Whitmore Lake are judged to be quite representative of legal-size fish in the lake during the year of 1953, as judged from the length-frequency and age-frequency data in Tables 4 to 8. For example, the trap nets caught bluegills abundantly down to a size of about five inches and an age of four years. Smaller and younger bluegills were taken infrequently, presumably because of limitations of the gear and not because of a scarcity of fish. On the basis of adequacy of sampling, the analysis of survival for the bluegill should be computed from data on Age-Groups IV to X. Correspondingly, for other species, survival should be based on Age-Groups IV to XV for the largemouth bass, III to VI for the black crappie, IV to VII for the pumpkinseed, IV to X for the rock bass, and II to VII for the northern pike. But when survival rates are computed on the basis of these data, the results are far from realistic for the bluegill (survival rate 9.1 per cent), crappie (5.9), rock bass (17.8), northern pike (75.3), and possibly for the pumpkinseed (33.6); the considerable dominance of a particular age group is the cause. Survival rates computed for some of these same species from age-frequency data starting at one year younger in age are likewise unrealistic for the bluegill (99.6), black crappie (88.8), and rock bass (93.8), but in this case the computed figures are far too high. It means that a precise measure of annual mortality rate for legal-size bluegills, crappies, pumpkinseed, rock bass, and northern pike in Whitmore Lake will require age-frequency analyses and population data over a period of years while the dominant Age Groups III or IV are running their course, and such studies are planned.

For the present, a reasonable estimate of survival rate is available only for the largemouth bass (58.4), in which the age-frequency distribution of fish over three years of age was quite normal; and present estimates of angling and natural mortality rates are limited to this one species. From a total annual mortality rate of 41.6 per cent, and from a population figure of 4,532 fish representing what is left at the end of a year of mortality, total annual mortality is computed to be $41.6/58.4 \times 4{,}532 = 3{,}228$. During a complete year just prior to the spring of 1953, anglers took a computed 707 largemouth bass from the lake, according to creel census estimates provided by Mr. Christensen (Table 3). Angler harvest of bass for the year 1952 is thus computed to be only 22 per cent of the total mortality among legal-size bass in the lake.

Total angler harvest of principal species for the years 1952 and 1953 (excluding winter for 1953), from data supplied by Mr. Christensen, is given in Table 3.

CONDITIONS OF POPULATION ESTIMATE

The population estimate by the mark-and-recapture procedure is based on two assumptions: (1) that the population is not being altered during the field operations by either migration, mortality, or recruitment due to growth, and (2) that either the marked fish are distributed at random among unmarked fish, or the collecting is randomly distributed over the lake. In the present study, these requirements were met closely.

During the netting period there was no functional inlet or outlet to the lake. There was only a limited amount of fishing done during this spring period, and very few fish were removed by anglers. Observed natural mortality on the lake was extremely low. During the netting period, fish in the lake were making very little growth, as shown by an analysis for several species of average lengths of fish caught during the period of April 17 to 30 as compared to those caught during the period of May 1 to 19. The 729 four-year-old bluegills taken in April averaged 6.36 ± 0.02 inches in length, whereas the 969 four-year-olds taken in May averaged 6.18 ± 0.02. For the various age groups of largemouth bass, May fish were not significantly longer than April fish—among four-year olds, as an example, 185 fish in April averaged 11.88 ± 0.06, whereas 284 fish in May averaged 11.64 ± 0.02. Furthermore, the scales of these fish, upon microscopical examination, showed either no, or very little, growth for the spring of 1953.

Random distribution of marked fish over the lake was assured by the large number of randomly distributed netting sites over the lake and by the liberation of marked fish at the site of capture. Furthermore, the collecting was randomly distributed over the lake (Table 1, and previous discussion).

TRAP-NET CATCHES AS INDICES OF POPULATION DENSITY

There is the question of how reliable trap-net catches might be for a direct estimate of population density. For example, if it proved to be true that trap nets of certain specifications consistently caught a certain percentage of the fish in a lake per given area, and if this percentage could be established, then trap-net catches subsequently could be used for a direct estimate of poulation density. Another possibility is that net catches per unit of net-effort and time-effort may be (in fact, are being) used as indices of relative abundance in comparing different waters, different parts of a lake, etc. In either case, the degree of precision which can be obtained is a function of the number of net sets and the degree of variability of individual catches.

On Whitmore Lake the individual net catches were so variable as to offer little encouragement for pursuing the question beyond a perfunctory comment. The 168 over-night trap-net sets had a mean catch of 18.1 ± 3.09 legal-size bluegills, with a standard deviation of 40, and a maximum range of 0 to 293. For legal-size largemouth bass the mean was 8.2 ± 0.93 with a standard deviation of 12 and a range of 0 to 79. Similar data for legal-size fish of other species are:

	Mean catch per net	Standard deviation
Black crappie	1.5±0.36	4.7
Pumpkinseed	0.5±0.08	1.0
Rock bass	0.8±0.12	1.6
Northern pike	0.5±0.07	0.9
Yellow bullhead	3.5±0.35	4.5
Brown bullhead	3.6±0.42	5.5

The figures on population density per acre (in Table 3) could be divided by the above mean catches to give conversion factors for computing population per acre from trap net catches, but the application of these conversion factors to mean catches of a relatively few net sets, or to catches made in other lakes, or even at other seasons on Whitmore Lake, would give highly questionable results. The same may be said for the use of mean catches as indices of relative abundance, in which the degree of precision would be little, if any, better.

The high degree of variability in net catches on Whitmore Lake was due to variability as related to depth of water, as related to date within the 33-day netting period (April 17 to May 19), as related to different geographical portions of the lake (Fig. 1), and as related, no doubt, to other factors such as type of bottom, abundance of vegetation, and other factors not considered in the present analyses. The mean catch per net and its standard deviation were computed for each species, legals and sub-legals separately, by 5-foot depth intervals, by three date intervals, and for four geographic areas of the lake. The data are given, in part, in Table 9. One of the unexplainable sources of variation was operating in the depth distribution of catches of legal-size bluegills which showed an affinity for consecutively alternate depth intervals from the 3-5 to the 30-35 interval; data for sub-legal bluegills (not included in the table) matches the pattern for legal-size bluegills. Largemouth bass were most abundant in 5-10 feet of water and were progressively less abundant in deeper water. Nets fished during the mid-part (April 28-May 8) of the netting period caught more fish than nets fished earlier (April 17-27) or later (May 9-19), presumably because of greater activity of fish during the mid-period. Certain species were more abundant in one particular "quarter" of the lake than in others, and this caried with time periods. The bluegill was least abundant in the northwest quarter (NW ¼) of the lake during the first time period, but the most abundant in this same quarter during the second time period; furthermore the bluegill was twice as abundant in the north half of the lake as compared to the southern half, for the netting period as a whole. Sub-legal bluegills showed the same abundance pattern as the legals. The largemouth bass, in contrast to the bluegill, was two to three times as abundant in the southeast quarter of the lake as elsewhere during the first third of the netting period, but had distributed itself quite uniformly over the entire lake by the final third of the period. Among the averages given in Table 9, in most cases the extreme differences within a given species are highly significant statistically.

PROBLEMS OF SAMPLING FISH FOR STUDIES OF AGE AND GROWTH

In general practice, samples of fish for age and growth studies are collected by a variety of gear, to different degrees of sampling intensity, and with different degrees of geographical coverage over a body of water. That these factors are important in causing bias in samples is at least suspected by most fisheries workers, and is well illustrated by some of the Whitmore Lake data. The trap-net catches of 3-year-old bluegills (Table 4) and of 2-year-old largemouth bass (Table 5) obviously were biased numerically and probably also as to length distribution. But, more importantly, the Whitmore Lake data show other types of bias which might often be overlooked.

One possibility is that age-frequency distribution might be related to depth. Among 1,293 trap-netted largemouth bass, 390 from 3 to 5

TABLE 9. CATCH OF LEGAL-SIZE FISH OF PRINCIPAL SPECIES PER NET-DAY BY TRAP NETS IN WHITMORE LAKE, APRIL 17 TO MAY 19, 1953, ANALYZED ACCORDING TO DEPTH OF WATER, GEOGRAPHICAL DIVISIONS OF THE LAKE (SEE FIG. 1), AND SUBDIVISION OF THE NETTING PERIOD

M = mean catch per net-day. SD = standard deviation of catch per net-day.

Water depth, ft.:		3-5	5-10	10-15	15-20	20-25	25-30	30-35
Number net sets:		48	52	22	16	13	12	5
Species								
Bluegill	M	32.3	6.7	28.8	2.6	18.3	3.3	36.2
	SD	43	13	68	3.6	42	6.4	79
Largemouth bass	M	7.8	13.3	6.7	5.1	3.8	1.5	1.4
	SD	11	17	7.1	7.5	5.8	2.3	3.1
Black crappie	M	1.8	1.9	1.4	0.2	0.8	0.8	0.8
	SD	7.5	3.8	3.2	0.4	1.3	2.0	1.8
Rock bass	M	1.8	0.6	0.3	0.3	0.4	0	0.6
	SD	2.6	0.8	0.7	0.6	0.8	0	0.9
Yellow bullhead	M	4.5	4.7	2.6	1.9	1.8	1.1	1.0
	SD	5.4	4.9	3.4	1.5	2.8	2.3	1.7
Brown bullhead	M	2.7	5.2	2.0	3.3	4.8	3.7	0
	SD	6.3	5.8	2.1	4.5	5.3	6.1	0

Geog. div.; date period:		NW ¼	NE ¼	SW ¼	SE ¼	Apr. 17-27	Apr. 28-May 8	May 9-19
Number net sets:		25	26	73	44	55	58	55
Bluegill	M	29.1	27.3	12.4	15.6	12.8	25.4	15.5
	SD	69	35	30	34	22	57	31
Largemouth bass	M	6.8	3.9	6.9	13.6	8.6	10.2	5.6
	SD	7.1	4.5	9.8	18	17	11	6.3
Black crappie	M	0.6	0.6	1.4	2.5	0.9	2.8	0.7
	SD	1.5	1.1	6.1	4.5	1.6	7.7	1.2
Rock bass	M	0.7	0.5	0.7	1.3	0.4	0.8	1.3
	SD	1.4	0.9	1.9	1.6	0.9	1.2	2.3
Yellow bullhead	M	2.4	4.2	2.7	5.1	2.3	3.9	4.3
	SD	3.1	3.9	4.1	5.6	3.8	4.4	5.0
Brown bullhead	M	1.4	4.4	2.8	5.8	4.4	4.2	2.2
	SD	2.3	6.2	4.3	7.2	6.7	5.3	4.0

feet of water had a mean age of 4.79 ± 0.09 years, 148 from 10 to 15 feet of water had a mean age of 5.30 ± 0.15 years, 48 from 20 to 25 feet of water had a mean age of 5.73 ± 0.33 years; the first group is significantly different from the second and third. For the bass, considering all depth intervals, there was not a significant correlation between average age and depth, but a significant variation between certain intervals was found. Among 1,877 bluegills, the older fish were generally in the shallower water, a condition possibly related to the approach of the spawning season. Average ages of bluegills for the seven consecutive 5-foot depth intervals, starting with shallow water, were 4.28 ± 0.04, 4.54 ± 0.14, 4.22 ± 0.03, 4.04 ± 0.08, 4.11 ± 0.03, 4.00 ± 0, and 4.17 ± 0.04. The first three are significantly different from the last four. Likewise, for the bluegill, the mean ages of fish from four geographic quarters of the lake were variable, with some statistically significant differences.

Among the 1,877 trap-netted bluegills on which age determinations were made, 1,698 (90 per cent) were in Age-Group IV. Their mean length was 6.26 ± 0.014 inches, range 4.6 to 7.8. The problem of adequate sampling is illustrated by one comparison which can be made for these four-year-olds. The 729 fish collected during April 17-30 in 29 trap-net sets had an average length of 6.36 $\pm$ 0.021 inches, while the 969 four-year-olds collected during May 1-19 in 23 trap-net sets had an average length of 6.18 $\pm$ 0.018; the difference is highly significant ($t = 6.7$). One possible explanation is that the four-year-olds shrank in length appreciably during this period, but the more likely explanation is that the difference was due to sampling bias combined with significant difference in the distribution over the lake of fast-growing and slow-growing four-year-olds.

The 1,698 four-year-olds were the combined total catch of 52 trap-net sets. Many of the 52 lots contained only one to five specimens, but many contained 40 or more. Among these lots of 40 or more specimens, the differences between sample means, and between a sample mean and the mean of the whole group, were, in many comparisons, highly significant statistically.

The conclusion is that the population of fish, by species, in a lake even as small as Whitmore (677 acres) is not distributed uniformly over the lake, even within a particular year class of one species. Rather there appear to be significant differences not only in abundance but in age- and size-frequency distributions with a given species. These differences were found to be related to depth of water and geographical locations on the lake, but the differences are probably primarily related to food, cover, and other factors vital to the fish.

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DISCUSSION

DISCUSSION LEADER CALHOUN: I notice you have a 10-inch size limit on your black bass. Does any information you have support the need for such a limit?

We recently discontinued that in California, and I wondered what your thoughts were on the matter.

DR. COOPER: Well, we recognized that many of the adjoining states are liberalizing regulations on predatory species. Some of the states, like Ohio, are way ahead of us in that regard. I guess most states are, as far as relaxing regulations are concerned, and perhaps we would be safe in going ahead and liberalizing the regulations much faster than we have done in Michigan. However, we have taken the point of view there that even though many of the states have gone on much more rapidly than we have, we would try to set up the liberalizations on an experimental basis in these studies on about a dozen lakes, and try them for five or six years and see what the results are before we go ahead generally with the liberalization.

We have population studies on one lake, Sugar Loaf, for a five-year period, and as I remember, approximately, we decided that the anglers were taking 50 per cent of the legal-size bass, and the other 50 per cent was just dying from some other cause.

You might conclude from this that you should liberalize to a much greater extent, to get a much higher proportion of all bass produced, but there is one joker in that argument, it seems to me, and that is that, obviously, anglers would never take a hundred per cent of the bass produced, because some of them are going to be bound to die naturally, and it's anybody's guess as to how far you can go in liberalizations until you have tested them and followed the fishing quality along to see what the results are going to be after a rather limited experimental basis.

I know that quite a few of the states are going ahead in rather extreme fashion without that supporting information, and probably they are perfectly safe. There is one thing we can say for sure—even though they have gone too far too fast, it would be a rather easy matter to back up, because most of these species would bounce right back in a couple of year even if you did overfish them one year.

MR. CALHOUN: I didn't mean to infer that Michigan was too slow in liberalizing. I have serious concern in this whole matter of harvesting black bass. The general conclusion we have had in the West, from eastern workers, has been that, in general, you couldn't overfish this type of fish, because when you've got them down to a certain point they stop biting. However, some recent tagging experiments have us kind of worried. We have had exceedingly large returns of tagged bass in the creel, running up around 60 or 70 per cent of tagged fish creeled, indicating that perhaps the pressures are excessive, and perhaps we are going a little too fast.

I wondered if you had found anything that confirms or refutes the need for the tendency.

DR. COOPER: In one of the latter tables there were figures on the catch of bass and the catch of all fish in '52 and '53. In '52 they caught only about 700 bass and about 4,500 in the spring of '53. During 1953 they caught two or three thousand—I forget the figure.

I think the thing we have to keep in mind is that even where a few of the bass live to be 10 or 12 years old, the great majority of them only live two or three years after they reach legal size. The age groups that are coming in—from sub-legal-size every year—are very large, so there is a very fast replacement.

I recall the figures that some of the folks in Ohio put out in checking on their experimental lakes where they have liberalized regulations. On the basis of their checks I think they concluded in the first two or three years that angling in any one year was taking something over a hundred per cent of what was there at the beginning of the year. Well, on the face of it, that doesn't sound possible, but on the other hand, was there at any one time, maybe, only about 50, 60, or 70 per cent of what goes through the lake in the course of the year?

MR. CALHOUN: We have some very serious problems in some of our southern California lakes, where we have many more people than fish. Some of our men have seriously proposed a 2-fish limit on the black bass, to ration them so more people will have a chance to catch them. That's how much pressure there is in our area.

MR. KENNETH M. MAYALL (Department of Planning, Toronto, Canada): I think Dr. Cooper said this idea of normal frequency is based upon populations gathered from statistics in other lakes.

DR. COOPER: Possibly each of us would have a little different idea as to what we mean by normal distribution of different year classes of any one species. If we had a random sample, we would expect to get a lot more one-year-olds than two's, and so on. Some of the figures compiled on age have given species for a state as a whole, where fish are collected not in one water but in different waters, by types, every year. Those figures will regularly show a decrease in numbers of fish in different year classes, as you get into the older year classes.

I have a vague concept of what the normal distribution would be in the case of bass—I think it is 15 of the 15-year-olds and 14-year-olds, and a couple of 13's, and two or three 12's, and 15 10's, and so on. The numbers there seem to be progressively orderly, and tail out at the end, but in the case of all the other species, such as the bluegill, over 80 per cent of all the fish were just 4-year-olds. There were about 15 or 20 times as many 4-year-olds and 5-year-olds. That is obviously a case of great year-class dominance; for some reason the bluegill reproduction in that year represented by the 4-year-olds must have been unusually successful, or else there was an unusually successful survival of the young.

THE EFFECTS OF A LATE-SUMMER DRAWDOWN ON THE FISH POPULATION OF RIDGE LAKE, COLES COUNTY, ILLINOIS

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Interest in the effects of fluctuating water levels in lakes upon the standing crop of fish was stimulated by the investigations of Dr. R. W. Eschmeyer and his colleagues (Eschmeyer and Jones, 1941; Eschmeyer, 1942; Eschmeyer, Stroud and Jones, 1944; Eschmeyer, Manges and Haslbauer, 1947) on TVA waters. Previously, Swingle and Smith (1938 and 1939) had demonstrated that the standing crop of fish in a pond bears a direct relationship to the area of the pond, and to its basic fertility. Krumholz (1948) was able to demonstrate an annual cycle in the total weight of the standing crop of fish in ponds in Michigan and Indiana and a gradual increase in the weight of fish supported by these ponds over a period of several years.

In a report presented at the Ninth Midwest Wildlife Conference in 1947, Dr. Eschmeyer stated that several permanent-level pools on TVA impoundments had provided poorer fishing than had other reservoirs that are subjected to wide fluctuations of water levels. He suggested that "the winter drawdown apparently limits the abundance of rough fish (by limiting their food), without serious injury to the game fish population.'' Drawdowns on TVA lakes followed no definite schedule, but most of the drop in level occurred in winter to follow needs for power.

In agreement with Eschmeyer's finding for permanent-level pools of TVA, our observations on fishing in stable-level water supply reservoirs in Illinois indicate that many of these waters become very poor for fishing within a period of a few years. A cycle of transition from good fishing to poor fishing in these reservoirs was described by the author in 1946 (Bennett, 1946).

If the weight of fish in a lake or pond is related to the area of productive water in that lake, any change in area will be reflected in an increase or a decrease in the weight of fish. Mild fluctuations of lake area, of short duration, might have slight influence upon the fish because of a time lag in population adjustment. However, severe, relatively sudden fluctuations, such as might result from prolonged floods or artificial drawdowns, might be expected to upset the entire ecology of the lake and exert sudden stresses upon the fish population. These stresses, which in the case of drawdowns might be related to available food supply, population density and/or predator-prey relationships, would have varying effects upon the several components of a fish population, not only among the species of fish present but also upon fish of various sizes belonging to a single species. The result might be that ''normal'' intra- and inter-specific competition associated with stable water levels would be replaced by new types and intensities of competition favoring certain components of the fish population over others, and eventually changing the dominance of certain species in favor of others.

By 1951, the fish population of Ridge Lake in Coles County, Illinois, had been studied for a period of 10 years in a series of five 2-year periods during which water levels were relatively stable (Bennett, 1954). These 2-year periods were delimited by lake drainings and fish censuses, followed by population adjustments and restockings, so that after several of these 2-year periods it was quite readily possible to estimate the degree of inter-specific competition between the two more abundant species of fishes and to predict the population expansion potential of other species in the lake. With this backlog of information on fish population behavior for this lake under stable water levels, it was believed that any population changes resulting from a severe artificial drawdown could be evaluated. At the time the drawdowns were planned, however, the extent of the fish population change that was to result from the drawdown was underestimated.

EXPERIMENTAL DRAWDOWN OF RIDGE LAKE

Ridge Lake has been described in some detail in a previous publication (Bennett, 1954). Briefly it is an artificial impoundment of about 17 acres (originally the area was 18 acres but silting has reduced the surface area and volume), located in Fox Ridge State Park near Charleston, Illinois; the lake has been used as an outdoor laboratory for study of the largemouth bass since water was first impounded and these fish were stocked in 1941. Throughout the months of June, July, and August of most years after 1941, the lake has been opened to public fishing under a system to obtain a complete record of the catch of fish. At two-year intervals, the lake has been drained (in March) to allow censusing of the fish. Selected, marked fish were returned following each of five draining censuses, and the lake usually had refilled again by the first of May. Ridge Lake contained largemouth bass alone from April, 1941, when it was first stocked, until July of 1944; bass and bluegills from July of 1944 to May of 1949; bass, bluegills and warmouth bass from May of 1949 until May of 1951, and bass, bluegills, warmouth bass and channel catfish from May of 1951 to March of 1953. A few green sunfish and black bullheads moved into the lake each year from the intermittent feeder stream above, and these fish were removed at the times of censusing.

In early September of 1951 and again in 1952, following summer fishing periods, the level of Ridge Lake was lowered 15 feet by opening a screened outlet. This reduced the lake area from 17 acres to 5.25 acres, and the maximum depth at the outlet from 25 feet to 10 feet. The drawdown was accomplished in about 36 hours. The reduction in surface area amounted to 69 per cent and, of course, the reduction in total volume was considerably greater. In both 1951 and 1952, the lake level remained low until December when runoff water began to refill the lake; in both years the lake basin had nearly refilled by early March. Lake surface water remained above 55° F. throughout September and early October in 1951 and 1952.

WEIGHT LOSSES OF THE POST-DRAWDOWN FISH POPULATION

The pre-drawdown censuses of 1947, 1949 and 1951 were considered more nearly valid for comparison with the post-drawdown census of 1953 than were the censuses of 1943 and 1945, because during the earlier period, from 1941 until July of 1944, the lake contained essentially a population of largemouth bass. Ridge Lake was stocked with 129 bluegills during July of 1944, and although they did spawn during July and August of that year, time was insufficient to allow a significant buildup of bluegill poundage before the spring census of

1945. By 1946, however, a large bluegill population had developed in the lake, and this component of the Ridge Lake fish population remained large throughout the rest of the period. The introduction of 138 warmouth bass in the spring of 1949 was followed by only a minor expansion of this population in the next four years, amounting to less than three pounds per acre in the 1951 census and 3.6 pounds per acre in the 1953 census.

On May 1, 1951, 675 channel catfish from 9 to 13 inches in length were stocked in Ridge Lake, and on November 5, 1952, 599 additional catfish were added. One hundred forty-three of the original 675 were caught by anglers in 1951 and 138 in 1952. There was no indication that these channel catfish produced young in 1952; they were probably immature in 1951. The channel catfish were introduced with the thought that they might assist the largemouth bass in consuming the excessive numbers of small bluegills that ordinarily were produced within the lake during the two years between draining censuses. The stomachs of 24 catfish taken during the summers of 1951 and 1952 did not contain any bluegills. However, channel catfish may have fed on small bluegills when the latter were more concentrated following the drawdowns. In retrospect, the addition of catfish was probably a mistake because these fish constituted an additional variable.

The poundages per acre of largemouth bass, bluegills and other fish found in Ridge Lake in the 1947, 1949, 1951 and 1953 censuses are shown in Table 1. While considerable variation in poundages of bass, bluegills, other fish and totals is shown in the three pre-drawdown censuses, the weights of these groupings were all larger than were comparable groupings in the post-drawdown census of 1953 (provided the poundage of stocked channel catfish is subtracted from the "other fish" grouping of 1953). With a reduction of lake surface area of 69 per cent, one might assume, if there is some direct relationship between lake surface area and standing crop of fish, that a near-comparable reduction would follow in the weight of the fish population, provided a sufficient length of time elapsed to allow such a readjustment (Swingle, 1939). The reduced poundage of fish taken in the 1953

TABLE 1. POUNDS OF LARGEMOUTH, BLUEGILLS AND OTHER FISH PER ACRE TAKEN AT RIDGE LAKE IN THE DRAINING CENSUSES OF 1947, 1949, AND 1951, AFTER TWO-YEAR PERIODS OF STABLE WATER LEVELS, AND POUNDS PER ACRE TAKEN IN THE 1953 CENSUS AFTER FALL DRAWDOWNS OF 1951 AND 1952.

	1947 Census	1949 Census	1951 Census	1953 Census
Largemouth Bass	31.5	50.4	49.9	26.6
Bluegills	193.3	86.9	105.2	58.3
Other Fish	31.5	2.9	8.7	32.0
Total	256.3	140.2	163.8	116.9

census suggested that such an adjustment was taking place, but that it had not progressed to its potential limit.

NUMBERS AND SIZES OF FISHES

One may estimate roughly the numbers of bass, bluegills and other fish of three inches or more in total length that were present in Ridge Lake in the summers of 1946, 1948, and 1950 when lake levels were stable, and in 1952 after the 1951 drawdown. These estimates are derived by the simple addition of the number of fish caught by anglers during any selected even-year season and the number found in the draining census of the spring following. Such a method of estimating numbers of fish is subject to the sources of error suggested by Lagler and DeRoth (1953, p. 245). In these numbers, shown in Table 2, no fish of less than three inches total length were included, because it has been impossible to make count of them on any draining census, and although visual estimates were made, the accuracy of such estimates may be questioned. Fish represented in Table 2 have been separated into "large" and "small" on the basis of their potential usefulness to anglers for sport and food. Designation of useful sizes was purely arbitrary and was as follows: Largemouth bass, 10 inches or longer; bluegills, green sunfish and warmouth bass, 6 inches or longer; bullheads, 10 inches or longer; and channel catfish, 12 inches or longer. A few carp were present in one census and they were all over 12 inches in length.

TABLE 2. APPROXIMATE NUMBERS OF FISHES LARGER THAN THREE INCHES TOTAL LENGTH THAT WERE PRESENT IN RIDGE LAKE DURING THE SUMMERS OF 1946, 1948, 1950, AND 1952.

	Largemouth Bass		Bluegills		Other Fish	
	Large[1]	Small	Large	Small	Large	Small
1946 Creel	206	156	733	953	80	204
1947 Census	401	1,608	6,873	49,754	209	397
Total Number	607	1,764	7,606	50,707	289	601
Combined Totals	2,371		58,313		890	
1948 Creel	363	285	2,301	3,530	168	73
1949 Census	1,027	1,012	3,089	16,625	82	24
Total Number	1,390	1,297	5,390	20,155	250	97
Combined Totals	2,687		25,545		347	
1950 Creel	236	279	386	509	90	186
1951 Census	537	973	663	50,300	88	1,013
Total Number	773	1,252	1,049	50,809	178	1,199
Combined Totals	2,025		51,858		1,377	
1952 Creel	137	639	1,522	1,597	219	25
1953 Census	138	1,826	4,419	3,057	830	107
Total Number	275	2,465	5,941	4,654	1,049	132
Combined Totals	2,740		10,595		1,181	

[1]The designation of "large" was: largemouth bass 10 inches or longer total length; bluegills and other sunfish, 6 inches or longer; bullheads, 10 inches or longer; catfish, 12 inches or longer; carp, 12 inches or longer.

The total numbers of bass have ranged between 2,025 and 2,740 in the four estimates, although the numbers of large and small bass making up these total counts have varied considerably. The greatest number of large bass was present in 1948 and the smallest number in 1952 after drawdowns were begun. To compensate for a smaller number of large bass in 1952, there was a larger number of small ones. From the standpoint of numbers of individual fish, no loss of bass can be demonstrated as a result of the drawdowns.

The estimated total numbers of bluegills in Ridge Lake in 1946, 1948, 1950 and 1952 varied more than those of bass (Table 2). In the three pre-drawdown estimates (1946, 1948 and 1950) the number was more than 50,000 in 1946 and 1950, and was 25,500 in 1948. In all three of these years, the numbers of bluegills of less than six inches in length exceeded the numbers that were larger: in 1946 there were nearly seven times as many small bluegills as large ones, in 1948 nearly four times as many, and in 1950 more than 48 times as many. The estimate of the number of bluegills in 1952 (probably reflecting the effects of both 1951 and 1952 drawdowns) amounted to about 10,600 fish, or only 41.5 per cent of the 1948 population which was the lowest of the three pre-drawdown estimates. Further, "large" bluegills outnumbered "small" bluegills (5,941 large to 4,654 small fish), a situation never observed previously in the experience of the author. Thus in spite of the fact that the total poundage of bluegills in the lake in 1952 must have been considerably lower than in 1946, 1948 or 1950, the number of fish of useful sizes available to anglers was exceeded only by the bluegills of useful sizes in the 1946 population. Unlike the numbers of largemouth bass, the numbers of bluegills were severely reduced by conditions that were assumed to have resulted from the drawdowns.

A comparison of the numbers of fishes other than bass and bluegills in the standing crop estimates of 1946, 1948, 1950 and 1952 (Table 2) is probably of little significance; because several kinds of fishes were involved, the number of any one species was relatively small, and 786 of the 1,181 fish in the 1952 estimate were introduced channel catfish. Exclusive of the channel catfish, the other fish in the 1952 standing crop estimate were 322 warmouth bass, (16 black bullheads, and 57 green sunfish. The comparatively large poundage of "other fish" shown in Table 1, for the 1947 census, consisted largely of 56 carp averaging nearly seven pounds each that are believed to have entered the lake from the Embarrass River below by swimming over the surface spillway in time of high water.

THE EFFECT OF THE 1951 DRAWDOWN ON THE BASS SPAWN OF 1952

Each year the success of the bass spawning at Ridge Lake is measured by making frequent counts of the number of schools of bass fry within the zone of shallow water along the lake margins, and estimating the numbers of fish in each school (Bennett, 1951, 1954). These estimates admittedly are inaccurate as far as actual numbers of fish are concerned, but the annual estimates have been made by the same individual using a standardized procedure throughout the thirteen years that the Ridge Lake experiment has been in operation; for this reason, it is believed that the estimated numbers of fry are comparable.

Estimates of numbers of bass fry produced during years of stable water levels, when the lake was not drained and the fish population was not culled of small fish, have shown that fry survival to the schooling stage in these years was relatively poor, particularly after 1945, when bluegills were abundant in the lake (Table 3). In years when the lake was drained in March and small fish were culled from the population prior to the bass spawning season, the production of bass fry was relatively heavy. This suggested that the survival of young bass to the schooling fry stage was controlled largely by the amount of predation from the small fish present in the aquatic environment.

The bass fry estimate for 1952 is shown with estimates of 1946, 1948, and 1950 (Table 3) because in 1952 there was no culling operation comparable to those of 1947, 1949, and 1951. However, the bass spawning season of 1952 was preceded by the September drawdown of 1951, while in other years water levels had remained stable for twelve months prior to spawning periods. The estimate of 34,500 bass fry produced in 1952 was similar to the numbers produced in years after small fish were culled at the time the lake was drained, and furnished

TABLE 3. ESTIMATES OF NUMBERS OF BASS FRY TO REACH THE SCHOOLING STAGE IN RIDGE LAKE DURING THE YEARS 1946 TO 1952 INCLUSIVE. THE LAKE WAS DRAINED AND SMALL FISH WERE CULLED FROM THE POPULATION IN MARCH OF 1947, 1949, AND 1951. SMALL FISH WERE NOT CULLED IN OTHER YEARS.

Year	Small fish were removed prior to bass spawning	Year	Small fish were not removed prior to bass spawning
	Estimated number of bass fry		Estimated number of bass fry
1947	37,000	1946	2,500
1949	24,000	1948	0[1]
1951	32,000	1950	0[1]
		1952	34,500[2]

[1]No schools of young bass could be found in 1948 and 1950. Extensive seining with a minnow seine produced no small bass in 1948; in 1950, one small bass was taken in one of five minnow seine hauls in the upper lake.
[2]Lake drawn down in early September of 1951.

evidence even before the lake was drained in 1953 that the drawdown was producing a severe culling action upon the small fishes.

YIELDS OF FISH

In the fishing season of 1952, anglers caught 776 bass (46 per acre) which was a larger number than had been taken in any previous season. However, the season was considered unusually poor because all but 137 of these bass were less than 10 inches' total length (7.5 to 9.8 inches) and belonged to the 1951 year class (unmarked fish). As mentioned above, the drawdown of 1951 apparently had little effect upon the survival of the 1951 year class of bass. The fact that fishermen caught nearly one-half of the larger bass available in the lake (Table 2) is unusual.

In every past two-year period between draining censuses at Ridge Lake, there has been unaccountable loss of marked bass. These fish were not caught by anglers during the summer fishing periods, they were not found dead at the lake surface, and they were not present in the lake when it was drained at the end of the two-year period. They could have moved out of the lake over the surface spillway on floods, or they could have died in the lake and failed to float, or some of them could have been taken by illegal fishing during periods when the lake was closed to fishing. In the 1951-1953 period, 108 fish or 13.4 per cent of the marked bass replaced in the lake after the 1951 draining were unaccountable. In the 1945-1947 period there was an unaccountable loss of 11.0 per cent, in 1947-1949, a 9.7 per cent loss, and in 1949-1951, an 11.1 per cent loss; so the 1951-1953 loss was higher than usual. This excessive loss may have been due, in part, to some poaching that was reported but could not be verified.

By weight, the 1952 catch of bass amounted to 15.8 pounds per acre, which was larger than the yield of 1946 (14.6 pounds per acre), but smaller than that of 1948 (25.6 pounds per acre) and 1950 (18.3 pounds per acre).

The bluegill catch in 1952 included 3,119 fish of which 1,522 were six inches or more in length, and 1,597 of less than six inches. Fishermen caught a smaller proportion of the large bluegills that were available in 1952 than were caught of those available in 1948 or 1950, but a larger proportion than in 1946 (Table 2). There is some indication that a moderate amount of food competition among bluegills improves bluegill fishing and when the bluegill population is below a certain numerical level, the competition for food is low and the fish do not need to forage widely. Yield figures show that 1948 was the best of all years for taking bluegills and in this year there were nearly four times as many small bluegills in the lake (exclusive of the 1948 hatch) as there were large ones.

The 1952 creel included 69 warmouth bass, 27 green sunfish, 138 channel catfish, and 10 black bullheads. Fish other than channel catfish made up only 3.3 per cent of the weight of those fish in the "other fish" grouping (Table 2).

The catch in 1952 was unusual only in the number of small bass taken and the fact that the bluegill catch of 31.1 pounds per acre was larger than in any comparable year except 1948. The bluegill catch in 1946 was 12.7 pounds per acre, in 1948, 45.9 pounds per acre and in 1950, 6.7 pounds per acre.

Fishing pressure in 1946 was 168 man-hours per acre, in 1948, 320 man-hours per acre, in 1950, 223 man-hours per acre, and in 1952, 290 man-hours per acre.

DISCUSSION

The concept of the use of the drawdown for the improvement of fishing is not new, but this concept has been based largely on circumstantial evidence. Wood (1951) published a comprehensive discussion of the drawdown and cited 85 references to substantiate his hypothesis as to how and why a drawdown improves the catch of fish. Yet, Wood was unable to cite any references that furnished statistics on how a drawdown actually affected individual components of a specific fish population.

This preliminary experiment at Ridge Lake suggests that there may be a considerable difference in the effect of a severe drawdown upon various segments of a fish population. The drawdown had almost no effect on bass numbers, while bluegill numbers among the small fishes were drastically reduced.

The September drawdown of 15 feet at Ridge Lake exposed the entire bottom of the littoral plant zone, which at that time of year was filled with fairly dense stands of potamogetons and other submerged-rooted aquatics. Small fishes and aquatic invertebrates inhabiting this zone were forced to move out of the vegetation into open water or become trapped in the plant mats as the latter were forced to the bottom and were finally exposed by receding waters. Many of the smaller fishes and aquatic insect larvae were trapped in the exposed mats of vegetation, and in very shallow depressions in the lake bottom that did not completely drain with the receding waters. These depressions were completely dry in three or four days.

The forced migration of aquatic animals from the protection of aquatic vegetation into the open water and the concentration of these animals in a reduced volume of water as the lake level receded made these food resources more readily available to the larger fishes. In each year, during the drawdown and immediately following, fishes were seen feeding in all parts of the lake. At the time of the drawdown, water temperatures ranged in the seventies (degrees Fahrenheit) and the rate of digestion and assimilation probably was rapid. In both years, the surface water of the lake remained above 55° F. until mid-October, limiting the period of rapid conversion of food to fish flesh to about one and one-half months. Although fish might be expected to continue feeding after mid-October, the low water temperatures would so reduce the rate of digestion and assimilation that growth would be nearly stopped.

The drawdowns probably caused a marked reduction in the invertebrate populations of Ridge Lake. In theory the effect of forcing these organisms to move from their normal habitats and concentrating them along a new shoreline, reduced in area and devoid of natural cover, would be a severe differential reduction in their numbers. Heavy losses could result from crowding, food competition, and predation in which some forms would be much more severely affected than would others. Eventually the surviving invertebrate populations would become somewhat stabilized within the new shallow water zone.

At this time, the reduced supply of fish food organisms, consisting of small fishes as well as invertebrates, might begin to exert an adverse effect upon the larger fishes. If the advancing fall season brought about a lowering of water temperatures, the stresses would be minimized and adjustments slowed.

With the early spring replacement of the lost water, new, uninhabited inshore waters would be created and invertebrate populations would begin expanding to repopulate them. As the expansion potential of these populations varies, one might expect a shifting of dominant forms until interspecific competitions again resulted in a more or less stabilized fauna.

It might be reasonable to assume that the drawdown would more quickly create a shortage among the types of small organisms upon which bluegills feed (Bennett, 1948) than it would among the larger food organisms better suited for bass. In the repopulation of a newly reflooded area, the reverse would be true; populations of entomostraca, for example, would expand much more rapidly than would those of large aquatic insects or crayfish. Thus the bluegills that survived a drawdown would find a great deal of available food in a recently flooded area, while the bass might find little food other than that of terrestrial origin.

In evaluating the effects of the 15-foot drawdown at Ridge Lake, one may conclude that the drawdown was too severe from the standpoint of its influence upon the bluegill population. The catch of bluegills in 1952, after the 1951 drawdown, was comparatively good but not equal to that of 1948. There is some evidence to indicate that a larger total population of bluegills would have given a better rate of catch, although the average size of the fish might have been less. Perhaps a drop in water level of 10 feet, which would have reduced the lake area by about 35 per cent, would have permitted a larger survival of bluegills and a somewhat larger bluegill yield in 1952 without seriously reducing either the growth rate of bluegills or the success of bass spawning.

This first experiment at Ridge Lake demonstrates the need for further experiments of an extended nature, on lakes where previous measurements of fish populations under stable water levels will allow an appraisal of the effects of drawdowns of various magnitudes. It seems probable that effects of drawdowns will vary considerably with individual lakes containing various species of fish, and that optimum drawdowns for individual lakes must be determined through testing.

The use of the drawdown is limited by the possibility of its physical accomplishment; artificial lakes supplied with a drain outlet present no problem, but few natural lakes will lend themselves to this technique, unless their outlets can be lowered and control gates installed. Small ponds might be pumped or siphoned, although in many cases this procedure would not be possible.

In the North, a drawdown might be impractical in shallow lakes and ponds because of the danger of winterkill of fishes, as in most years sufficient runoff water to refill the lake basin will not be available until late winter or spring. In spite of these factors which restrict its widespread use, the drawdown as a management tool merits much further study.

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DISCUSSION

MR. RUDY STINAUER (Illinois Department of Conservation, Sterling, Illinois): What was the relative decrease in volume?

DR. BENNETT: Just as a guess, I think that the reduction in volume might be as much as 75 per cent.

MR. CALHOUN: Wouldn't you say, Dr. Bennett, that the reduction in area was the important thing, rather than the drawdown?

MR. IRVIN ROSE (Iowa Conservation Department, Des Moines, Iowa): Dr. Bennett, would it be possible to accomplish the same result in lakes that you can't drain by deliberately destroying, by something like Dave Thompson has done in some of the other areas?

DR. BENNETT: We have certainly considered that. The feeling I have is that you never quite know where you stand. You have no idea what the total population is. You just have to guess, when you kill a certain part of the population, that it is enough. The unsatisfactory thing about that is the indefiniteness of it.

MR. ADREY E. BORELL (U. S. Soil Conservation Service, Albuquerque, New Mexico): I didn't quite understand why the drawdown had so much more adverse effect on bluegills than on bass.

DR. BENNETT: I don't understand that myself. Obviously, though, there is a very definite differential in population reduction in that lake as a result of something that we attribute to the drawdown, because never before, under stable water levels, had we ever had such a small bluegill population.

INVESTIGATIONS OF WATERS BELOW STORAGE RESERVOIRS IN TENNESSEE

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The following are some of the data and observations made in the past three years (1951, 1952, and 1953) while conducting an ecological survey of the waters which flow from the high, tributary stream dams in the Tennessee Valley. The work has been conducted by the Tennessee Game and Fish Commission and is a Dingell-Johnson Project. The project will terminate in June of 1954, when the entire findings will be published. It is presented here in this form in order that some of the more pertinent findings can be made available to workers throughout the country.

The river below the dam, from the dam downstream to the mouth or to the next reservoir, is the tailwater and will be referred to as such throughout this paper.

The tailwaters which have been under study are: South Holston, Watauga, Wilbur, Norris, Cherokee, Douglas, Calderwood, Apalachia, Dale Hollow, and Center Hill. These ten areas comprise a total of more than 320 river-miles. Douglas tailwater is turbid and supports a heavy warm-water fishery. The remaining nine areas are beautiful clear-water streams, except during unusually heavy rains. Were it not for the success of the rainbow trout and the occasional migratory runs of several warm-water fish, the tailwaters would be very unproductive.

Why is it that these rivers, which were once very productive and supported excellent populations of warm-water game and food fish, became almost completely devoid of game fish after the dams were constructed? The answer to this question along with an attempt to restore a game fishery are the purposes of this project.

The obstruction of these rivers by large dams would not in itself have been too drastic nor overly important to the aquatic life in the river below. There were other high dams in the Tennessee Valley at the time Norris Dam was constructed in 1937, and they were causing very little change in the fishing pattern in the rivers below them. The important factor involved with the TVA dam construction was in the type and location of the power intake. Before Norris, most of the power intakes were near the upper levels of the dam located in such a position that the water drawn through the penstocks was taken from the epilimnion or thermocline of the reservoir. This caused the discharge of water to be at or near atmospheric temperatures and pressures. The TVA dams were constructed so that the power intake was located very low on the dam. At full reservoir level in summer this intake would be more than 100 feet below the surface of the reservoir. A typical reservoir profile would be much like Figure 1, which shows the temperature and dissolved oxygen content of Watauga reservoir. Therefore, the water taken from this low level in the reservoir and discharged into the tailwater would be cold to cool at all times, and the dissolved oxygen content would vary with the presence or absence of a density current in summer and the prevailing oxygen content at other times of the year. The density currents (Wiebe, 1940) are typical of all deep tributary stream reservoirs and account for this unusual temperature and dissolved oxygen profile.

The chemical and physical properties of the water immediately below the dam are dependent upon these factors in the reservoir at the point of power intake. As the water moves away from the dam downstream other conditions begin to act upon it and tend to characterize each tailwater. In order to see this picture more clearly, note the an-

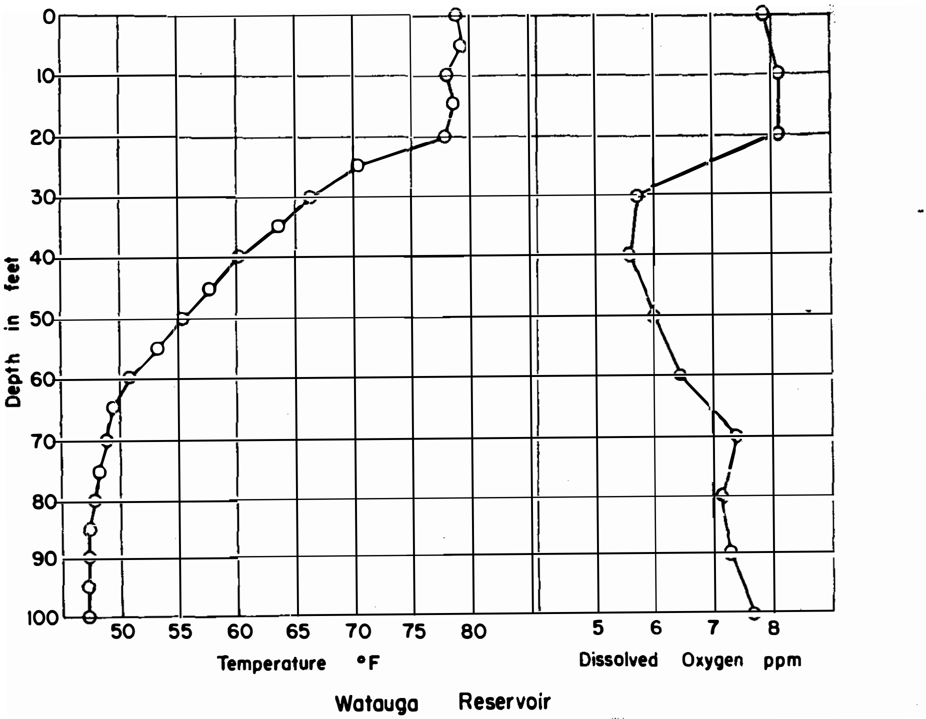

Figure 1. Temperature and Dissolved Oxygen Profile of Watauga Reservoir, July 1951.

nual trend in dissolved oxygen and temperatures for Cherokee tailwater (Fig. 2). Beginning in January the temperature is near 40° F. and the dissolved oxygen near 12 ppm. At this time of year the reservoir is at its lowest level. The temperature gradually rises until it reaches about 78° F. in September, while at the same time the dissolved oxygen gradually decreases until it is reduced to less than 1 ppm. in August and September. At this time of the year temperatures as high as 70° F. have been recorded in Cherokee reservoir at a depth of 70 feet. All reservoirs are at their highest elevation in July. Following this maximum, there is a rather sudden decrease in temperature and an increase in the dissolved oxygen until December. This reservoir has no apparent density currents. Watauga tailwater (Fig. 3) is in direct contrast to that of Cherokee in that there is very little fluctuation of temperature. The maximum temperature of near 55° F. occurs in October. The dissolved oxygen, however, follows a much more erratic pattern, fluctuating up and down in its general trend downward to 2 ppm. in November. The fluctuations occurring in July and August are the result of the density currents in the reservoir which happened to occur at the level of the power intake.

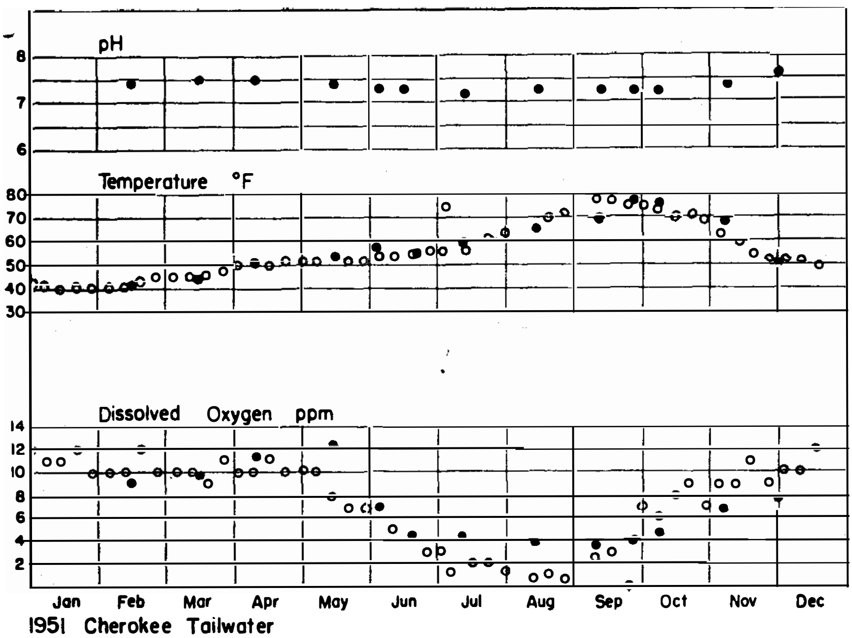

Figure 2. Annual Water Chemical Cycle for Cherokee Tailwater 1951.

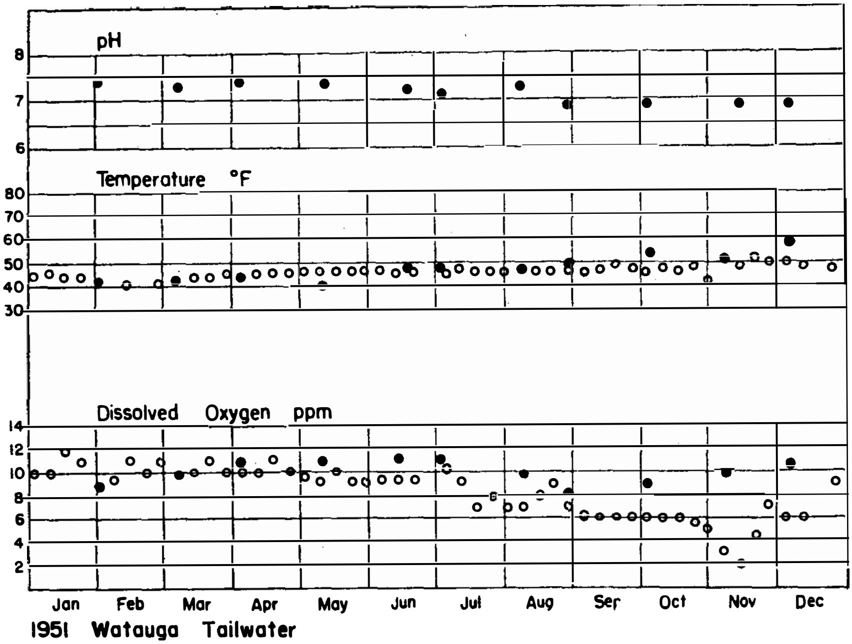

Figure 3. Annual Water Chemical Cycle for Watauga Tailwater 1951.

Another factor entering the picture at Cherokee, other than the absence of a density current, is the fact that Cherokee is relatively shallow with a large inflow of water. This has a warming effect in the summer. Briefly, the effect is this: As the cool water is drawn off the lower levels of the reservoir for power production and discharged into the tailwater it is replaced by warmer water. This continues until most of the reservoir is warm throughout. The same situation exists in Douglas reservoir. All of the other tributary stream reservoirs are much deeper and the inflow of water is relatively less, so that density currents and storage impoundment stratification takes place.

Tailwaters are subject to extreme fluctuation in velocity and volume of flow. Maximum discharges occur at periods of peak electrical demand, which occur on week days beginning at about 6 a.m. and lasting until about 9 p.m. This is sharply contrasted by the periods of reduced discharge or no discharge, which is usually at night and on week-ends. This constant change in velocity and volume of water has a very harsh effect on the tailwaters.

All of these factors have had a very definite and radical effect on the ecology of the stream below the dam. The first and most pronounced effect the dam has had on the river below it is a general lowering of the temperature of the water. This is made evident by a reduction of the extremes of temperature range. Where the water at one time reached a maximum of 80-85° F., and a minimum of 32-34° F., it now has an average range of from 39-65° F. The annual average is usually between 50° and 55 F.°

The dissolved oxygen content which formerly followed the general seasonal pattern for any rapidly moving, unpolluted, warm-water stream now has an entirely different pattern. It is very near saturation during the winter months and very near zero during September, October, or November depending on the particular waters involved. These periods of low dissolved oxygen seem to have very little effect on fish activity. Successful fishing takes place right up to the dam, even when the water being discharged contains less than 1 ppm. of oxygen. The reaeration of the water during one of the critical periods is shown for Cherokee tailwater in Table 1, taken from the unpublished data of the TVA Health and Safety Division. The increase in dissolved oxygen is rather gradual and has not recovered to the point of saturation in 50 miles. At the same time the temperature has changed very little. A very striking contrast to the above rate of reaeration can be seen in Table 2, which shows the reaeration of Little Tennessee River below Calderwood Dam. In a distance of 3.9 miles, the per cent saturation of dissolved oxygen changes from 65.2 per cent to 93.0 per cent or very near saturation. The reason for this difference in the two rivers is clearly illustrated in Table 3, which contains the reaeration coefficients for a pool reach and a shoal reach. The rate of absorption of oxygen in a shoal reach is much greater than in a pool reach. It is this fact which causes the very fast moving waters of

TABLE 1. REAERATION OF HOLSTON RIVER BELOW CHEROKEE DAM[1]

		Daylight, Sept. 20, 1949			Darkness, Sept. 21, 1949		
Location	Mile	DO ppm	Temp. C	Per cent Saturation	DO ppm	Temp. C	Per cent Saturation
Cherokee Penstock	52.2	0.80	23.3	9.6	0.0	23.9	0.0
Bridge Below Dam	52.0	1.51	23.4	18.0	2.38	22.2	27.9
Mile 45.0	45.0	2.50	23.6	30.1	2.39	21.2	27.6
Mile 43.3	43.3	3.22	23.6	38.7	2.90[2]	21.2[2]	33.5
Mile 42.2	42.2	3.34	23.6	40.1	2.99	21.3	34.5
Indian Cave	40.0	3.50	23.7	42.2	3.02	21.2	34.8
Mile 25.1	25.1	5.05	23.6	60.6	5.25	21.1	60.3
Mile 20.6	20.6	5.27	23.0	62.7	5.31	20.4	60.3
Mascot Bridge	17.0	5.70	22.1	66.7	5.82	21.2	67.1
Highway 70 Bridge	5.4	6.13	22.0	71.5	6.27	19.9	70.3
Boyd Ferry	1.8	6.22	23.0	73.9	6.45	20.4	73.2

[1]From the unpublished data of the T. V. A. Health and Safety Division.
[2]Interpolated.

TABLE 2. REAERATION OF LITTLE TENNESSEE RIVER BELOW CALDERWOOD DAM[1]

	September 7 and 8, 1949								
	In Daylight						In Darkness		
Location	Mile	DO ppm	Temp. C	Per cent Saturation	Time of Water Travel (Days)	Reaeration Coefficient	DO ppm	Temp. C	Saturation
Calderwood Penstock	42.5	6.22	16.5	65.2					
1400′ below Power H...	42.2	6.48	18.1	70.3	.0188	9.7			
Gaging Station	41.2	7.42	18.1	80.4	.0204	11.9	6.45	16.2	67.1
Mile 39.8	39.8	8.19	18.1	88.8	.0220	9.4	7.30	16.2	75.9
Mile 38.6	38.6	8.58	18.1	93.0			7.70	16.5	80.6

[1]From the unpublished data of the T. V. A. Health and Safety Division.

Calderwood, Wilbur, South Holston, and Apalachia tailwaters to re-recover a large amount of dissolved oxygen in a short time, while the rivers below Norris, Cherokee, Douglas, and Watauga Dams recover very slowly.

These various chemical and physical changes have caused radical alterations in the plant and animal life. Two very striking examples show the effect on the fish population. An unpublished pre-empound-

TABLE 3. REAERATION COEFFICIENTS FOR HOLSTON RIVER BELOW CHEROKEE DAM[1]

		Data Observed on Sept. 20 and 21, 1949 Average Discharge—7400 cfs									
				Daylight, Sept. 20				Darkness, Sept. 21			
Mile		Time	Time of Water Travel (Days)	DO ppm	Temp. C	Sat. DO ppm	DO Deficit ppm	DO ppm	Temp. C	Sat. DO ppm	DO Deficit ppm
45.0	Shoal	2:30pm	.0237	2.50	23.6	8.32	5.82	2.39	21.2	8.68	6.29
43.3		3:07pm		3.22	23.6	8.32	5.10	2.90	21.2	8.68	5.78
25.1	Pool	5:44pm	.0848	5.05	23,6	8.32	3.27	5.25	21.1	8.70	3.45
20.6		7:28pm		5.27	23.0	8.41	3.14	5.31	20.4	8.81	3.50

Reaeration Coefficient, k_r

Shoal Reach, Day, $k_r = \frac{\log 5.82 - \log 5.10}{.0237} = 2.42$

Night, $k_r = \frac{\log 6.29 - \log 5.78}{.0237} = 1.55$

Pool Reach, Day, $k_r = \frac{\log 3.27 - \log 8.14}{.0848} = 0.208$

Night, $k_r = \frac{\log 3.45 - \log 3.50}{.0848} = -0.074$

[1]From the unpublished data of the T. V. A. Health and Safety Division.

ment survey in 1947 by Charles J. Chance and Reeve M. Bailey in South Fork of the Holston and Watauga Rivers recorded 43 species for South Fork and 32 species for Watauga. After construction of the dam and subsequent discharge of cold water, only 17 species of fish have been recorded for South Holston tailwater and 13 for Watauga and Wilbur tailwaters on the Watauga River. The species which have disappeared have been primarily minnows. The species which have thus far remained in South Holston tailwater are:

Moxostoma breviceps—Shorthead redhorse
Moxostoma carinatum—River redhorse
Hypentelium nigricans—Northern hogsucker
Hybopsis micropogon—River chub
Notropis photogenis—Silver shiner
Notropis coccogenis—Warpaint shiner
Campostoma a. anomalum—Ohio stoneroller
Noturus flavus—Stone cat
Percina caprodes burtoni—Holston logperch
Etheostoma camurum (Taken during June 1949)—Bluebreast darter
Etheostoma blennioides newmannii—Greenside darter
Micropterus d. dolomieu—Northern smallmouth bass
Lepomis m. macrochirus—Northern bluegill
Ambloplites r. rupestris—Northern rock bass
Cottus c. carolinae—Tennessee banded muddler
Rhinichthys cataractae—Longnose dace[1]
Rhinichthys atratulus—Blacknosed dace[1]

The species remaining below Watauga and Wilbur tailwaters are:

Salmo gairdnerii irideus—Rainbow trout
Catostomus c. commersonnii—White sucker
Hypentelium nigricans—Northern hogsucker
Rhinichthys atratulus obtusus—Mountain blacknose dace
Hybopsis micropogon—River chub
Notropis photogensis—Silver shiner
Notropis coccogenis—Warpaint shiner
Campostoma a. anomalum—Ohio stoneroller
Micropterus d. dolomieu—Northern smallmouth bass
Ambloplites r. rupestris—Northern rock bass
Cottus c. carolinae—Tennessee banded muddler
Carpiodes velifer—Highfin sucker[1]
Ictalurus furcatus—Blue catfish[1]

Most of these species show little or no reproduction. An observation very similar to that found by Eschmeyer and Smith (1942) below

[1]Not recorded by Chance and Bailey.

Norris dam has been found for most warm-water species in the tributary stream tailwaters; namely, a condition of the ovaries in which the eggs are held long beyond normal spawning time and new eggs are formed around the old egg mass.

The plant population has been somewhat more difficult to follow with respect to presence or absence prior to dam construction. However, it has been very noticeable that certain plants have become dominant since construction of the dams. In every respect this has been an alga. In Norris and Cherokee tailwaters the most abundant form has been *Cladophora crispata*. In these two areas this species has become abundant to such a depth that the U. S. G. S. surface water gauges must be corrected to allow for the false bottom made by the alga. In Norris this alga harbors large populations of Tendipedid larvae and scuds of the genus *Gammarus*.

In South Holston tailwater *Ulothrix rivularis* is the dominant plant at present and also harbors insects of some importance. *Nitella flexilis*, an alga which is of prime importance at Calderwood tailwater, is beginning to populate the main channel.

In Watauga tailwater, which is actually the reservoir of Wilbur Dam, two algae share the dominance. These are *Spirogyra* sp. (probably *S. setiformis*), occurring throughout the lake as huge sterile filaments forming great masses of floating and attached plants, and *Chara contraria*, which occurs in unusually great mats of exceedingly long strands. These mats occasionally float to the surface. When attached to the lake bottom, great numbers of invertebrate forms occupy the mats. The occurrence of these two plants in Watauga tailwater is probably the most important secondary factor in the success of this water as a trout fishery.

Trout stocked in the tailwaters ingest large amounts of algae and it is believed that they derive nourishment from it. The plants are definitely broken down in the lower alimentary canal and must be partially digested.

Interesting trends in the invertebrate bottom fauna have taken place in these waters. The example used to illustrate the changes that have taken place in this group of animals is taken from the study of South Holston tailwater. This is the only area where samples could be taken prior to the time water was discharged from a full reservoir, and consequently gives some idea of the population of the unaltered river.

By examination of Table 4 it can be seen that the most obvious change that has taken place is in the number and volume of the organisms per square foot at Stations 3 and 4. The increase in numbers was the result of the tremendous upsurge of Simuliids, Tendipedis,

TABLE 4. AVERAGE NUMBER AND VOLUME IN CUBIC CENTIMETERS OF BOTTOM ORGANISMS FOR STATIONS 3 AND 4 IN SOUTH HOLSTON TAILWATER COLLECTED IN 1951, 1952, AND 1953

	1951				1952				1953			
	Station 3		Station 4		Station 3		Station 4		Station 3		Station 4	
	Av. No.	Av. Vol.	Av. No.	Av. Vol.	Av. No.	Av. Vol.	Av. No.	Av. Vol.	Av. No.	Av. Vol.	Av. No.	Av. Vol.
January	....	....	22.2	0.57	11.3	0.23	18.2	0.32	....	....	....	....
February	5.66	0.75	....	....	....	....	....	....	91.5	1.63	74.7	2.06
March	10.0	0.28	20.2	0.57	31.6	0.23	15.2	....	....	....	....	....
April	11.0	1.32	....	....	21.5	1.32	6.7	1.39	99.5	1.20	68.0	1.92
May	14.6	1.28	17.2	0.40	54.6	0.17	....	....	....	....	....	....
June	13.6	0.96	....	....	82.7	0.52	25.5	0.89	....	....	....	....
July	21.6	0.93	29.7	0.63	....	....	....	....	105.7	2.12	84.7	3.49
August	38.3	1.02	....	....	....	....	....	....	....	....	....	....
September	40.0	1.35	....	....	134.7	0.99	47.5	1.37	....	....	....	....
October	43.3	0.73	....	....	....	....	....	....	....	....	....	....
November	44.6	1.11	26.7	0.51	....	....	....	....	114.2	1.85	113.5	3.28
December	64.3	1.83	....	....	95.0	1.76	68.5	1.86	....	....	....	....

scuds of the genus *Gammarus,* and the gradual increase in numbers of Trichoptera of the genus *Hydropsyche.* These organisms had little effect on the total volume, since, at the same time, the numbers of *Acroneuria internata* (a large species of Plecoptera), most of the Ephemerids, and *Corydalus cornutus* (the large hellgramite) were diminishing. Volume increase can be attributed almost entirely to the increase in numbers of snails. The Plecopteran species, *Acroneuria internata, Taeniopteryx nivalis,* and *Neophasganophora* sp. and *Corydalus cornutus,* have disappeared from the samples taken at Station 4. They occur only occasionally at Station 3.

Station 3 and 4 are long shoal areas three and eight miles downstream from the dam respectively.

All of the other tailwaters which have been established for several years show that the trend taking place at South Holston is normal. In Norris and Watauga tailwaters Tendipedids, *Gammarus,* and snails are the dominant forms. In Calderwood tailwater *Simulium* and *Hydropsyche* are dominant. In Wilbur tailwater the dominant forms are *Simulium* and *Gammarus.* Snails are common to abundant in most all tailwaters. The most notable exception to this trend is found below Cherokee Dam where extremely few bottom organisms of any group are found.

All of the above tailwaters, with the exception of Douglas, have been stocked with trout at one time or another. Cherokee and Center Hill Tailwaters received heavy experimental releases of rainbow, brook, and brown trout and as yet, three years later, neither area has produced a trout fishery. The remaining six areas have received heavy plantings of rainbow and brook trout, and in no case has the brook trout survived long enough to produce a desirable fishery. This has not been the case for the rainbow trout, however. Phenomenal growth rates and exceptional survival have been recorded, and an excellent fishery has been established. This has been done with plantings of fingerling rainbow trout ranging in size from two to five inches. These small fish begin growing almost immediately and show no complete cessation of growth at any time of the year. The only exception occurs among the few fish which migrate out of the main stream into tributary streams to spawn. Here a spawning check can be found in the scale. Several individual rainbow trout (80) were followed during a spawning migration for a period of seven weeks, and a regular and gradual reduction in weight was noticed.

The data concerning fish populations will be reported in full at the completion of the project, and it will suffice here to mention that average growth equals approximately one inch per month and that condition (K) factor as high as 2.65 has been recorded for the rainbow.

SUMMARY

The construction of large dams in the Tennessee Valley has caused major changes in the ecology of the waters below them.

A lower average temperature, 50-55° F., a reduction of the extreme temperatures, 39-65° F., and an erratic seasonal dissolved oxygen pattern has resulted.

Great daily fluctuations in water velocity and volume take place.

These changes in water have brought about great changes in the plant and animal populations. Many of the minnow species have disappeared. Only a few species of those remaining are successfully reproducing. The bottom faunal pattern has changed from large warm-water species to small cold-water species. The most abundant groups are members of the insect families Tendipedidae, Simuliidae and Hydropsychidae along with the scud, *Gammarus,* and snails. The plant populations are dominated entirely by algae of several species. These plants attain tremendous growths in some areas.

Experimental planting of rainbow trout fingerlings has shown that this species is very well suited for continued management. Brook trout have not survived tailwater conditions.

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DISCUSSION

MR. MAYALL: I would be interested to know what method you used to collect the bottom organisms in this particular investigation.

MR. PFITZER: With a typical square-foot bottom sampler. The specimens were separated from the debris and then a volume and total count were obtained.

A tremendous amount of data has been compiled on this project. I tried only to give you an idea of the problems that were involved in undertaking this project. Incidentally, it was done by only one individual most of the time. I mean there was no crew to do the field work or laboratory work. A lot of data has been left out for the sake of brevity.

DR. SHETTER: Where do the rainbows go when you have those rather rough conditions of low oxygen content and high temperature in the fall of the year?

MR. PFITZER: They stay in the tailwaters. Apparently they survive those low oxygen concentrations. Now they are farther downstream, where the reabsorption of dissolved oxygen has taken place, if you see what I mean. We have taken rainbow trout in areas where the dissolved oxygen concentration was around 2 parts per million.

DR. SHETTER: In other words, a fisherman has to take a chemical and physical reading before he goes fishing?

MR. PFITZER: No, that wouldn't be necessary, because after the person once learns to fish the area, the fish localize themselves in the river very interestingly. I couldn't show that here, but there are some very interesting localizations of population throughout the various lengths of the stream. Some of them are up to 50 miles long.

CHAIRMAN SMITH: I would like to inquire about the relative effect of this decrease in fish. One of the problems that always comes up when a new reservoir is proposed is the question of what the relative values are. Not infrequently, an estimate of the increase in fish production is put forward as one of the values of the reservoir. Do you have any estimates or opinions on the relative influence of the decrease in game fish in the tailwaters on the over-all production of fish associated with the reservoir?

MR. PFITZER: I might point out here that I will not attempt to answer questions referring to the reservoir itself. In the tailwaters it is my belief, since we haven't been able to understand most of the areas prior to impoundment, that the increase in rough fish—red horse, suckers, fish of that type—the increase in poundage and perhaps the increase in numbers (I haven't been able to prove that conclusively) in these areas is subject to tremendous migrations of fish from impoundments below, so you can't evaluate the data on the basis of a number of population studies without going where those fish came from.

The point is that there is very little natural reproduction; the game fish decrease in number. The population, then, after impoundment, is made up of rough fish. As to its total effect, I can't answer that now.

DR. SHETTER: Have you any evidence that the rainbow trout are reproducing in these tailwaters?

MR. PFITZER: Yes, we have evidence that a limited amount of reproduction is taking place. It is very small. Upward of 500,000 fingerling trout have been fin-clipped and stocked in the tailwaters, or will have been stocked by the end of this year.

The recovery rate of fin-clipped to non-fin-clipped trout has been about 10 to 15 per cent non-fin-clipped to fin-clipped fish in the over-all average. In some area it is greater, and in some it is less.

But there is a small amount of reproduction, and I believe I am safe in saying that most of it occurs in tributary streams to the tailwaters. These large rainbow run out of the main tailwater stream, out of the main river, into tributary streams, where they spawn. The fingerlings move out of the tributary sreams into the tailwaters, and in that way they help populate the tailwaters.

MR. WALTER W. AITKIN (Corps of Engineers, Missouri River Basin, Omaha, Nebraska): I understood you to say that oxygen in the discharged water is recovered in three miles. Was that correct?

MR. PFITZER: If you have a stream in which there is a large amount of shoal area, or rapids, the recovery of oxygen is naturally very rapid. If you have an area where the river is composed primarily of pools, with very little shoal areas, then the absorption of dissolved oxygen from the dam downstream is very slow.

MR. AITKIN: Specifically, I wondered what the recovery was, progressively, in feet or yards or whatever your measurements may have been. What recovery of oxygen takes place below the dam?

MR. PFITZER: Well, for Calderwood Tailwater, which is on the Little Tennessee River, with an area of a large number of shoals and rapidly moving water, the dissolved oxygen content is 6.2 at the dam. In 2 miles it recovers to 7 parts per million, and in the additional third mile from the dam it goes up to 8.58 parts per million per mile.

In contrast to that, on Cherokee, you have an entirely different situation. In 50 miles you get very little or a very gradual increase in dissolved oxygen. I have the data here, but it was not shown.

TECHNICAL SESSIONS

Tuesday Morning—March 9

Chairman: DANIEL W. LAY
Wildlife Biologist, Texas Game and Fish Commission, Buna, Texas

Discussion Leader: LEVI MOHLER
Research Biologist, State Game, Forestation and Parks Commission, Lincoln, Nebraska

UPLAND GAME RESOURCES

THE INFLUENCE OF HUNTING AND OF RAINFALL UPON GAMBEL'S QUAIL POPULATIONS

WENDELL G. SWANK AND STEVE GALLIZIOLI
Arizona Game and Fish Commission, Phoenix

Within the past few years some of the emphasis in wildlife management has shifted from production to measurement of the proper harvest. It is true that the major proportion of wildlife research and management is devoted to *producing* more game and fish for the hunters and fishermen, but sprinkled throughout technical and popular publications devoted to reporting progress of wildlife management activities, one finds such titles as "Hunting Pressure and Its Effect on Bobwhite Quail Populations" (Parmalee, 1953), "Effect of Hunting Pressure on a Valley Quail Population" (Glading and Saarni, 1944), and "Are Hunting Laws Obsolete?" (Linduska, 1952).

Delving into the influence of hunting upon populations, and such biological phenomena as longevity, population turnover, and the ability of a population to "bounce back" after decimating factors have taken their toll is, we believe, both a progressive and an essential trend in the wildlife management field. The implications in the quest for this type of knowledge are well expressed in the opening paragraph of an article by Linduska (1952) in which he asks, "Are we making the most of our upland game crops—or are we plowing under a part of each year's surplus? Can we have more game to shoot by shooting more game?"

Evidently warm-water fisheries biologists are convinced that fishermen can have more fish merely by catching more. This is illustrated by the wholesale adoption of year-long seasons and elimination of creel and size limits by state fisheries agencies.

Do the same biological conditions that have caused this relaxation of harvesting controls in fisheries apply in the field of upland game management? Wherever it has been put to the test it appears that they do apply, but perhaps to a lesser degree. At the termination of the reproductive season more individuals are present than can be supported by the habitat. Removing a portion of these animals provides more food and better cover for those individuals remaining. It would seem that there is constant and immediate adjustment of wildlife populations to the current carrying capacity of the habitat.

Quail, like our other upland game species, are geared to a high reproductive rate and a high annual mortality. For bobwhite quail (*Colinus virginianus*) numerous studies have shown that this high mortality occurs whether hunting does or does not take place. Results of studies by Errington and Hamerstrom (1935), Baumgartner (1944), Mosby and Overton (1950), and Kozicky and Hendrickson (1952), all illustrate that hunting does not exert a permanent depressing effect upon bobwhite populations. Mortality, due both to hunting and natural causes, is offset by a high rearing success and survival of young the following summer, if reproductive conditions are favorable.

Thus far the western quails have not received the attention of the investigations that has been devoted to the bobwhite. A review of the literature revealed only a single study by Glading and Saarni (1944). After a four-year investigation they concluded that hunting was not a factor controlling populations of the California valley quail (*Lophortyx californica*).

With the tremendous increase in Arizona's human population within the past few years, and indications that this rate of growth will not decline, it seems possible that our game populations may eventually be called upon to absorb hunting pressure equal to that now present in the East. In view of this it was thought desirable to investigate the influence of hunting on Gambel's quail.

GAMBEL'S QUAIL AS A GAME SPECIES

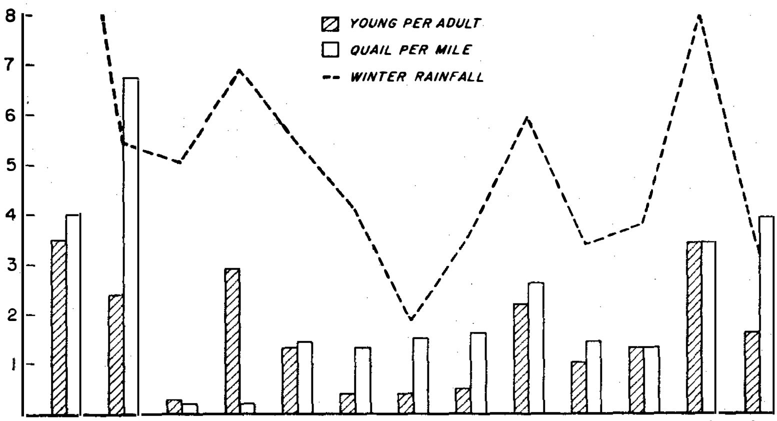
This bird is Arizona's number one upland game species, both from the amount of area it occupies in the state, and the number of hunters it brings into the field. Generally speaking, the Gambel's quail in

Arizona is found in the southern half of the state except in the scattered mountain ranges at elevations above 5,000 feet. Cacti of various species stand out as the predominant vegetation in the landscape, except at the upper fringes of the range where the low desert is replaced by a yucca-grassland type. The abundance of cacti, particularly the cholla group, practically eliminates the dog from the hunting scene. Also, the rough terrain throughout much of the bird's range considerably restricts the activities of the hunter.

At the time of the hunting season, birds are in large coveys numbering from 20 to 200, with the usual number in the vicinity of 40 birds. At the beginning of the season, particularly in areas of minimum cover, birds are prone to run, rather than hold for the hunter. Not infrequently the whole covey may run, then flush beyond shotgun range. Once the covey is broken up, singles have more of a tendency to hold for the hunter, flush, and fly in typical bobwhite fashion. Birds hit but not retrieved are numerous, as cripples readily run and hide under brush or disappear into the abundant rodent burrows. The fall colors of the bobwhite country are missing, but are compensated for by the ruggedness of the terrain and the invigorating dry atmosphere.

INFLUENCE OF RAINFALL AND HUNTING ON PAST POPULATIONS

Gambel's quail populations fluctuate greatly in Arizona (Figure 1). In 1941 a standardized roadside survey covering the major ranges of



YEAR	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953
YOUNG/ADULT	3.5	2.4	0.3	2.9	1.3	0.4	0.4	0.5	2.2	1.0	1.3	3.4	1.6
QUAIL/MILE	4.0	6.7	0.2	0.2	1.4	1.3	1.5	1.6	2.6	1.4	1.3	3.4	3.9
HUNT (DAYS)	15	30	15	15	15	0	0	0	2	2	2½	15	16
RAINFALL (INCHES)	13.0	5.39	5.04	6.84	5.34	4.03	1.82	3.52	5.91	3.38	3.75	7.83	3.15

Figure 1. Gambel's quail population fluctuation over a 13-year period, based on a standardized survey covering major Arizona quail ranges, correlated with winter rainfall and hunting seasons.

the quail was established by T. L. Kimball (1948). The results of this survey over the past 13 years show that the peak population was reached in 1942. That year 6.7 birds were observed per mile of travel. This followed a year (1941) in which the ratio of young to adult was the highest yet recorded, 3.5 to 1. Either in the winter of 1942 or spring of 1943 the "bottom fell out" of the population. Data from the 1943 summer survey show that quail had reached an all-time low of 0.2 birds per mile and only 0.3 young per adult. This low in population followed a 30-day hunting season, which was double the usual length at that time.

In 1944 the birds staged a weak comeback by producing 2.9 young per adult. The over-all population was so low, however, that only 0.2 birds per mile of survey were observed. Since that date there has been an upward trend, except for a temporary recession in 1950 and 1951.

Hunting as a limiting factor.—The crash in population that occurred between the 1942 and the 1943 surveys understandably created a cautious attitude in Arizona towards overhunting of quail. Factual data in any quantity concerning this crash are lacking, for at that time everyone was busy fighting a war. We can therefore only examine the information that is available, and draw our conclusions. From the data at hand it appears that hunting pressure in 1942 could not have been appreciably greater than it was in 1941, even though the season was longer. There were 1,980 more licenses sold in 1942 than in 1941, but gasoline rationing went into effect on December 1, ten days after the season began. Department records show a noticeable drop in hunters passing through the Oracle Junction quail checking station after initiation of gasoline rationing. Furthermore, sporting ammunition, on which manufacturing had ceased the preceding May, was extremely difficult to obtain.

That the crash in population did not occur prior to or during the hunting season is attested to by such newspaper accounts as the following: *Phoenix Gazette,* November 14, "Best quail prospects in years." *Phoenix Gazette,* November 20, "Enthusiastic reports of lots of quail came in from virtually every area." *Phoenix Gazette,* December 22, "Quail season unanimously voted to have been the best enjoyed by hunters for years." It appears then that those hunters who had sufficient ammunition and gasoline enjoyed unexcelled hunting throughout the season. The crash in population must have occurred between December 20, 1942, when the hunting season ended, and July 1943, when the annual quail survey was run. Could a note in a Department report (Sparks, 1943) be of significance? This note says, "Drought conditions existed for one year prior to the 1942 (quail) season, resulting in a drop of ground vegetation."

Rainfall as a limiting factor. As early as 1941, Kimball noted the correlation between high annual rainfall, good quail hatches, and high survival of young. The 13 years of data now available show how closely this pattern of correlation follows. A deviation exists only in 1942 and 1953, and in both instances the pattern was similar (Figure 1). This similarity leads us to propose the following hypothesis.

Weather records show that 1941 was a year marked by an abundance of winter rains—as was 1952. This resulted in an abundance of vegetative growth on the desert, providing conditions suitable for an unusual rearing success. Rainfall during the winter of 1941-1942 was below normal, as it was in 1952-1953, resulting in a lower rearing success, but sufficient food (mainly seeds) was "carried over" from the spring of 1941 to sustain the birds through the 1942 hunting season. However, sometime between December 20 and July this "surplus" food ran out, and the crash came. (At the present time, February 1954, the relatively high population resulting from the 1952 rearing season is holding up well.)

If the above hypothesis is acceptable as an explanation for the high 1942 and 1953 populations it then appears that the rise and fall of Gambel's quail population in Arizona is almost wholly dependent upon a good growth of spring vegetation. In the desert country, the range of the bird in question, production of green vegetation in the spring is primarily dependent upon the quantity of rainfall received during the preceding winter months. A ratio of more than two young to one adult occurred only during those years when the accumulated rainfall from December through April amounted to more than the average of 5.58 inches. Of the 13 years for which records are available, two or more young per adult were found only in 1941, 1942, 1944, 1949, and 1952.

It appears that factors controlling nesting of Gambel's quail in Arizona parallel those of the bobwhite on semi-arid southwestern ranges. In Texas, Lehmann (1953), demonstrated that successful nesting of the bobwhite was tied in closely with rainfall, which in turn stimulated growth of food plants suitable for building up a high vitamin A reserve in the birds. During periods of poor reproduction or high mortality, vitamin A reserves were below normal.

Annual turnover. From the high proportion of adult birds carried over from 1941 to 1942 and from 1952 to 1953 it appears that high annual mortality is not constant for Gambel's quail, as it is for the bobwhite. Like the production of young, mortality fluctuates greatly, as illustrated in the differences in the 1942 and 1943 population levels.

Undoubtedly one of the best indications of population turnover is the ratio of young to adult in the late summer or early fall population. For the bobwhite, Mosby and Overton (1950) in Virginia over a six-year period found an adult to immature ratio of 1 :4. In Iowa, Kozicky and Hendrickson (1952) in an examination of 914 birds in 1944 found a ratio of one adult to 3.7 young, and in 1948 an examination of 2,327 bobwhite wings showed a ratio of one adult to 6.83 juveniles. In the last 13 years the highest ratios obtained for Gambel's quail were 3.5 young per adult in 1941 and 3.4 young per adult in 1952. These data were from the summer surveys. Arizona checking station data, which are comparable with that information for the bobwhite in Iowa and Virginia, show 2.2 young per adult in 1952. This was considered an excellent production year.

EFFECT OF HUNTING AT ORACLE JUNCTION—AN INTENSIVE STUDY

Procedure. A review of past information did not provide data of a conclusive nature on the effect of hunting on Gambel's quail; therefore, an intensive study was initiated in 1951. Two areas near Oracle Junction, which lies 21 miles north of Tucson, were selected as the study site. One area was opened to an unlimited number of hunters during the regular hunting season, the other was closed to quail hunting.

In 1951 quail population estimates were made before and after the hunting season by observers walking transect lines. Direction of the lines was obtained by compass bearings.

In 1952 both the hunt and the control areas were reduced in an attempt to obtain more reliable results. Also the running of lines by compass was abandoned for lines pre-marked with cloth strips.

In order to test the validity of walking transects as a census method one line was run five times in 1951, and in 1952 two lines were run five times each. Results of these replicates show that variabilities were high (Table 1). Statistical analysis indicated that if variabilites remained at the level obtained in the preliminary runs it would be neces-

TABLE 1. RESULTS OF PRELIMINARY SURVEYS TO TEST VARIABILITY

1951		1952			
		Transect 1		Transect 2	
Date	Quail seen	Date	Quail seen	Date	Quail seen
Nov. 8	75	Sept. 10	131	Sept. 10	67
Nov. 9	72	Sept. 12	75	Sept. 12	45
Nov. 10	76	Sept. 15	107	Sept. 15	68
Nov. 13	49	Sejt. 17	25	Sept. 18	30
Nov. 14	2	Sejt. 18	75	Sept. 18	0

sary to increase the sample 12 times, or walk approximately 1,456 miles of transects on the area, in order to detect a 10 per cent change in population at the 95 per cent confidence level. Further analysis indicated that to obtain reliable results it would be necessary to have a strip every 75 yards along a mile front.

The combination of large coveys into which Gambel's quail gathered, and the probability of encountering those particular coveys while covering the transect resulted in too much variability.

Since economic considerations prohibited the use of the quantity of man hours necessary to procure reliable data by walking transects, a system of trapping and banding was set up in 1952. The population was then determined by ratio of banded to unbanded returns as illustrated by Lagler (1950). It now appears that this method is not a satisfactory one for determining Gambel's quail population numbers. Instead of getting an estimate of the whole population, a figure is obtained for only a portion of the birds occupying an area.

To determine the number of birds removed from the study area and to gather information on sex and age ratios, hunters passed through a checking station when leaving the area. Information was also gained at the checking station from those who hunted adjacent to the study area.

In 1951 the hunted area was the only one open to quail hunting within the vicinity of Tucson. The season was three days long. In 1952 and 1953 most of the state was open to quail hunting, except for the control area upon which no hunting was permitted. The lengths of the seasons were 14 days in 1952 and 16 days in 1953.

Population estimates. As shown by the previous discussion, lack of a perfected census technique leaves the validity of our data open to question. We believe, however, that the results obtained are quite indicative. In order to standardize presentation of results, numbers herein presented were reduced to quail per ten acres (Table 2).

Probably the first thing that is apparent to those who have worked

TABLE 2. POPULATION CHANGES, QUAIL PER TEN ACRES BEFORE HUNTING (NOVEMBER) AND AFTER HUNTING (JANUARY) ON A HUNTED AND ON A NON-HUNTED AREA

	Non-hunted area			Hunted area			
Year	Pre-hunt	Post-hunt	Change in population	summer (August)	Pre-hunt	Post-hunt	Change in population
1951	3.61	6.13	+70%	[1]	8.84	6.09	−31%
1952	8.06	5.59	−31%	11.63	6.71	5.49	−18%
1953[2]		5.04		11.11	7.14	5.57	−22%

[1]No survey made in August 1951.
[2]Survey figures obtained by trapping and banding.

TABLE 3. BOBWHITE QUAIL POPULATIONS, QUAIL PER TEN ACRES

Virginia[1]		Iowa[2]		Oklahoma[3]		Texas[4]	
Year	Fall population	Year	Fall population	Year	Fall population	Year	August population
1935	0.9	1941	2.2	1939	2.5	1949	12.9
1936	0.7	1942	3.2	1940	0.9	1950	12.8
1937	1.3	1943	3.8	1941	2.2	1951	3.6
1946	0.9	1944	3.2	1942	2.5		
1947	1.0	1949	0.6	1943	1.8		
1948	1.1	1950	0.7				

[1]Mosby and Overton, 1950.
[2]Kozicky and Hendrickson, 1952.
[3]Baumgartner, 1944.
[4]Lehmann, 1952.

with the bobwhite is the comparatively high populations of Gambel's quail found on unmanaged desert lands. Note that in late summer in both 1952 and 1953 populations on the hunted area exceeded one quail per acre. From a review of the literature we found that only in south Texas do bobwhite populations compare with those obtained for Gambel's quail on the study areas (Table 3).

The second obvious factor is that the density of birds on the two areas was not comparable. Populations were higher on the hunted area than they were on the non-hunted one. This is attributed to the lighter grazing pressure, hence better habitat conditions, on the hunted area. Gorsuch (1934) made an extensive study of the Gambel's quail in Arizona and concluded that "Overgrazing, a condition more common than grazing in moderation, is seriously detrimental to quail."

In 1951, survey data for the non-hunted area showed a 70 per cent increase in population from November to January. No plausible explanation for this increase is available. It seems improbable that influx caused this increase, for our banding data indicate no great movement at this time of the year. The most plausible answer is error in sampling. For the hunted area, the count dropped from 8.84 birds per ten acres to 6.09 birds per ten acres, a change of 31 per cent in population. This perhaps seems like quite a removal of birds, but doubtless few areas in Arizona will frequently be subjected to the hunting pressure that occurred on this area in 1951. Only very small portions of the state were open to a two and one-half days hunt on an experimental basis. Within the two and one-half days, 1,594 hunters entered the area and bagged 3,162 quail.

In 1952 a survey was made the latter part of August in the hunt area to determine if natural mortality factors began to take their toll before opening the hunting season. As pointed out by Lay (1952) for the Texas bobwhite, when heavy mortality occurs in the fall, December hunting is too late to utilize the surplus properly. Our data show that on the hunt area there was a drop from 11.63 birds per ten acres in August to 6.71 birds in late November, a decline of 42 per cent. The pre-hunt survey on the non-hunted area showed 8.06 birds per ten acres. In January the same type of survey over the same area yielded 5.59 birds per ten acres, a drop of 31 per cent. On the hunted area the population of 6.71 birds prior to the hunt had dropped to 5.49 birds by the middle of January, a drop of 18 per cent. The overall decline on the hunt area from 11.63 birds in August to 5.49 birds in January was a drop in population of 53 per cent.

Information in 1953 was obtained by a different method; it can therefore be questioned whether it is directly comparable with that from the two previous years. They should be comparable, however, on the hunted and non-hunted areas. Data for 1953 were obtained in the following manner: By trapping, banding, then setting up a ratio of banded to unbanded birds in the re-traps, a population of 3.4 birds per ten acres was obtained on the hunted area just prior to the hunt. Calculations based on the ratio of banded to unbanded birds returned by hunters showed a population of 7.14 birds per ten acres. During the trapping period we were well aware of the fact that certain birds day after day were coming in contact with our traps but were not entering them. We, in effect, were obtaining figures for only a portion of the population that occupied the area. Dividing 3.4, the population obtained by trapping, into 7.14, the population obtained by hunting, we obtained a conversion factor of 2.1. Since all indications pointed to the fact that hunting gave a much more valid sample of the true population than did trapping, those figures obtained by trapping were multiplied by the 2.1 conversion factor. We then see (Table 2) that our population on the areas intensively studied compares fairly well with the data of the previous year. The fact that populations per mile were rather close both years on the standardized state-wide survey also lends support to the use of data obtained in this manner (Figure 1).

In 1953 data on the non-hunt area were obtained only once, and that during the last week of the hunting season. The 5.04 birds per ten acres agrees closely with the post-hunt data for 1952. On the hunted area the 1953 August population of 11.1 birds per ten acres agrees closely with the population figure obtained in August of 1952. Also the data for pre- and post-hunt periods in 1953 agree rather closely with those obtained in 1952.

The change in population brought about by hunting on the hunted area in 1952 and 1953 certainly does not seem excessive. It is a well accepted biological principle that the number of young produced is indicative of expected mortality. At the Oracle Junction checking station in 1952 there were in the hunter bag approximately two young for each adult. This would indicate that the fall population was about three times as great as the nesting population. At this same ratio, it would be expected that for every three birds alive after the hunting season only one would survive to reproduce its kind. In all probability that proportion of the birds removed by hunting would have been lost to natural mortality factors if they had not been eliminated from the area. Note that there was no increase in population on the non-hunted area. In fact, there was a slight gradual decrease over the three-year closure period. Studies on the bobwhite similar to this one have also failed to detect a distinct increase in population on areas where closure to hunting has been the only measure applied. Ridley (1952) in a study of unmanaged quail refuges as a restoration technique consistently found higher fall populations on some hunted areas than on some of those areas closed to hunting.

Hunt data. In 1951 the limited area within the state open to quail hunting resulted in heavy pressure on the hunt area. Hunters checked 3,162 quail through the station (Table 4). All of the 1,594 hunters did not hunt within the boundaries of the study area; however, a good proportion did confine their activities to that locality. The season was too short to determine if there was a gradual decline in birds bagged per hour with progression of the hunt. The average number of quail bagged per man hour was 0.43 and 79.5 per cent of the hunters obtained the bag limit of five birds.

The 1952 season of 14 days and 1953 season of 16 days provided an opportunity to test hunter success by birds bagged per man hour of hunter effort (Figure 2). This, to some degree, should be indicative of the birds available to the hunters each day. The results of these data show no decline in birds bagged per hour of hunter effort as the season progressed. In the latter part of the season birds bagged per hour was equal to or above the average. This is in contrast to data obtained by Allen (1947) on a heavily hunted pheasant population, where hunter success declined as the season progressed. He showed that 70 per cent of the birds were bagged the first week, yet only 50 per cent of the hunting occurred during this period.

TABLE 4. HUNTING STATISTICS FROM ORACLE JUNCTION CHECKING STATION

Statistic	1951	1952	1953
Length of season (days)	2.5	14	16
Number of hunters checked	1,594	1,099	1,471
Number of quail bagged	3,162	4,304	4.807
Average bag per hunter	2.0	3.9	3.2
Average quail per hour	0.43	0.99	0.96
Young per adult	0.8	2.2	0.8
Young per adult female	2.0	5.18	1.86

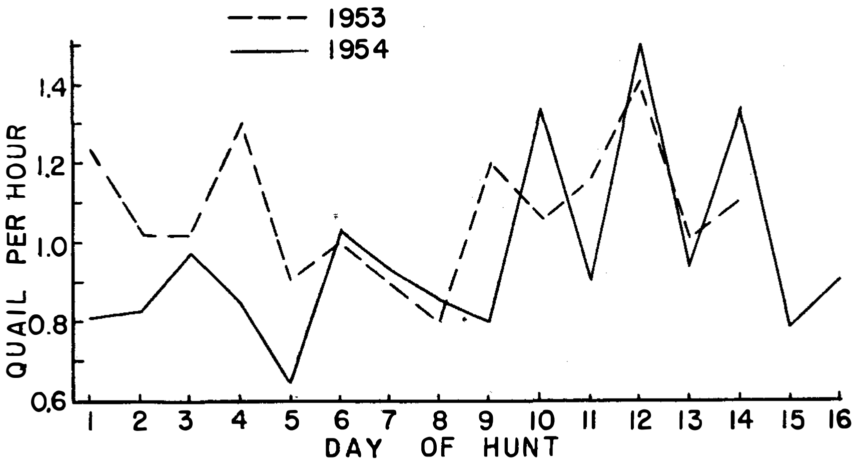


Figure 2. Quail bagged per hour of hunter effort, Oracle Junction area.

In 1953 the average hunter success, as measured by birds bagged per hour of effort, was slightly below that for 1952 (Table 4), although pre-hunt surveys showed a slight increase in population over that of the previous year. The increase in time required to obtain a bird may be attributed to the smaller proportion of younger quail in the 1953 bag, for it appears that birds of the year more readily fall to the hunters' guns than do adults. Checking station data for 1953 show that during the first five days of the hunt juvenile birds made up 49 per cent of the bag, during the second five days juveniles made up 40 per cent, and during the last six days 37 per cent of the bag were young birds.

In 1952, when the proportion of juveniles in the population was higher, young birds the first five days made up 70 per cent of the bag, and the last nine days 68 per cent of the bag was made up of young quail.

This is similar to that data obtained by Allen (1947) and Kimball (1948) who showed that in pheasants taken by hunters the proportion of young birds making up the bag decreases as the season progresses. The effect of hunting on our area was rather light. Otherwise, as pointed out by Petrides (1949), the difference in the proportion of young birds making up the bag at the beginning and at the end of the season would have been greater. In South Dakota young pheasants made up 83 per cent of the bag the first week, but only 54 per cent the last week (Kimball, 1948).

MANAGEMENT IMPLICATIONS

Although data herein presented indicate that hunting had no permanent depressing effect, some still question whether it is good management to hunt when populations are at a low point. Information from surveys the past 13 years clearly indicates the great annual population fluctuation that can be expected in the future. The increase in numbers from 1951 to 1952 also illustrates the ability of the Gambel's quail almost to triple in population when excellent conditions for reproduction occur.

Another species noted for its fluctuation in numbers and sudden drop in population is the ruffed grouse. Although it differs from the Gambel's quail in many respects perhaps it would not be amiss to review some interesting information on this bird. Linduska (1952) pointed out that during the last high in the grouse cycle, over a four-year period Michigan and Minnesota harvested an approximate equal number of birds; about 1,200,000 each. On the low of the cycle Minnesota was closed to hunting for a four-year period, but Michigan hung on to its usual season and took off 800,000 birds. In 1948, after a four-year closure, Minnesota harvested around 354,000 birds. Michigan took slightly more than this number. Linduska's comment, "It would appear that through a succession of closed years Minnesota 'plowed under' at least 300,000 and possibly up to three-quarters of a million birds." Whether Gambel's quail would react in a manner similar to ruffed grouse is problematical, but the present study on the effect of hunting should be continued throughout a series of "lows" in population. If hunting has no apparent depressing effect during the "lows," as has been demonstrated during the "highs," a moderate hunting season during depressions in population should be in order.

How heavy should hunting be during the "highs" in population? Our data indicate that a fair proportion of a population produced in a good year is carried over and results in a high population at least for one additional year. If future studies produce data of a similar pattern, extremely heavy hunting would be in order at least in the second year of the high. In retrospect, it certainly would have been good management to have harvested more heavily in 1942. A heavier harvest in both 1941 and 1942 may have "buffered" the crash that followed, for undoubtedly the food supply would have lasted longer for those individuals remaining after the hunting seasons.

SUMMARY

Information on fluctuation of the Gambel's quail population in Arizona over the past 13 years indicates that the amount of rainfall

during the winter months, December through April, is the factor limiting abundance. Hunting was not responsible for the crash in population that occurred between December 20, 1942 and July 1943. Also, there was no noticeable rise in population from 1946 through 1948 during a complete closure to quail hunting throughout the state.

In a three-year study conducted on a hunted and non-hunted area, post-hunt populations on both areas were about the same. Pre-hunt populations were somewhat lower on the non-hunted area, due to the lower density of ground vegetation. On the hunt area it was calculated that 31 per cent of the quail population was removed in 1951, 18 per cent in 1952, and 22 per cent in 1953. During the period of study, in which there was an upward trend in statewide quail population, the amount of hunting applied on the study area did not permanently depress quail numbers. Heavy hunting is in order for those years when a high in population occurs. It will be necessary to continue the study through a low in population density before recommendations can be made concerning the feasibility of harvesting during population depressions.

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DISCUSSION

DISCUSSION LEADER MOHLER: Gentlemen, we don't want to penalize our speaker for starting late. We do want to have some discussion. Is there a question? I know many of you have had bobwhite experience and I think Gambel's quail is new and as I look at the picture, I begin thinking of some sort of a space suited for a hunting dog, with all those stickers.

DR. SWANK: If nobody is going to discuss it, I would like to discuss it myself. I remember back in San Francisco, Earl Frye said he felt even in Florida where they had dogs, horses, guides, all the facilities, that he was pretty sure that it was practically impossible to overshoot the bobwhite quail. I would like to ask him if he still has that same theory.

MR. EARL FRYE (Florida Game and Fresh Water Fish Commission, Tallahassee, Florida): Our ideas along that line are becoming more and more crystallized. We definitely feel in Florida it is very seldom if ever that quail are overshot. They are shot to where hunting is poor, but we think the law of diminishing quail takes over before quail are ever damaged in that country.

I was interested in the very low reproductive rate. We run around 70 to 80 per cent and higher in quail and we figured that was quite possibly one of the reasons that you can't overshoot quail because we normally have this high reproduction.

DR. SWANK: I think in the young to adult ratio, you will find there is a turnover in Gambel's quail that is not as rapid as in the bobwhite. We have very little severe weather in the winter and undoubtedly our food is a limiting factor, as shown by the trends; if we have good food which is provided by winter rains, we get a high young to adult ratio. The only time we get a marked decrease in our population from fall to spring is when we have had poor rains, and evidently our population will carry over at least one year.

MR. I. O. BUSS (Washington State College, Pullman, Washington): I had a question similar to the one Mr. Frye just asked in relation to turnover. The figure 2.2 per young per adult is very low as far as bobwhite is concerned. Your population ran as high as 11 plus birds per ten acres, which is very high. Do you have any specific figures on turnover?

DR. SWANK: We have just started our banding program down there. Dr. Sowls, I believe, is in the audience, and he has been conducting some banding programs there. I told him I would like him to speak for himself. But I believe it is generally accepted that the young per adult is pretty indicative of the population growth. It is entirely possible that the young may not survive, because they are competing with the adults for food and cover. The number of eggs laid by Gambel's quail is pretty similar to that of the bobwhite.

DR. LYLE K. SOWLS (Cooperative Wildlife Research Unit, Tucson, Arizona): I think the years 1952 and 1953 had about the same total population, but there was a great difference in the adult to young ratio and I think the reason for that is, in 1952 we had the first good year for many years. We were coming out of a low slump and then in 1952 we didn't get the reproduction, but we didn't need it so badly because we had so many adult birds carried over.

We have been banding quail for a turnover study for three years and we find about 30 per cent of the adult birds live to the next year. We get some birds where the population is four years old, and I think the total number of adults carried over from one year to another is higher than the bobwhite quail.

MR. BUSS: How large was the total area on which you worked?

DR. SWANK: The area referred to is 15 miles on one side and 8 on the other.

DR. SOWLS: I would like to add one thing about the density per square mile. It may be a little misleading to some of you. These Gambel's quail in a lot of places are not distributed evenly. In some of our study areas we took the number of birds per square mile and per acre. You get about ten birds per acre. When you go to other large areas, you get no birds at all. So, we cannot apply the acres per bird in the same sense as the bobwhite quail. There are tremendous voids and tremendous concentrations to deal with and to iron out that would be giving the wrong impression. I don't think Wendell means this population was distributed uniformly over the whole area.

MR. JAMES HALE (Wisconsin Conservation Department, Madison, Wisconsin): It is true that age ratios are often fused to the turnover of the adult in the county population. However, in some quail, the ratio of young to adult changes from month to month. This is reported for California quail 15 years ago. That result has been to use age ratios very carefully, because we can't work with this species and determine the ratio of young to adult changes throughout the fall and winter. With an adult mortality rate in quail we have a rate of exploitation that has to be much lower than in the bobwhite. If we are faced with an adult mortality rate 80 per cent in bobwhite, it would take about 50 per cent of the population in the fall before it passes through the winter cutback.

With some of the western quail, such as the California quail, the mortality rate in that species would be 50 per cent. Hunting would affect population. That has been shown by literature published by Clay and his colleagues.

DR. SWANK: We are, of course, all aware that the young to adult ratio changes throughout the year. From those four surveys we got as high as 3.2 young per adult which you can get from the fall population from hunting. Also, I don't mean to imply that hunting does not affect our fall population, because as I explained in the introduction, the birds have the ability to bounce back after mortality factors have taken their toll, providing feeding conditions and reproductive conditions are satisfactory.

Perhaps there hasn't been enough hunting in some areas to see if we get a larger supply or if a larger proportion has been moved. That would be the next phase of our experiment.

MR. FRYE: I would like to make one more remark about the overshooting of the bobwhite. We feel there is one exception to this general statement that quail are rarely overshot. That occurs on these areas where by intensive management, the quail population is built up extraordinarily high and in such places, I think with very intensive hunting, it would be possible to shoot the population below a level from which it could recover in one year. But I don't think you find that situation as a rule.

STUDIES OF AUTOMATIC QUAIL FEEDERS IN FLORIDA

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Feeders for game birds and mammals have been in use for many years—principally in northern areas as a means of supplementing natural foods during periods of winter food shortages. In addition, attempts have been made in various places to increase quail populations by the use of artificial feeders or simply grain scattered upon the ground. Prior to the present study, however, there has been no comprehensive attempt to evaluate the use of feeders as a managment tool for bobwhite quail in the Southeast.

The feeder technique has received generally popular support because of its simplicity and its appeal to the average wildlife enthusiast who can see in the providing of food for obviously hungry wildlife a direct and easily comprehensible approach to the problem of insuring its welfare. Unfortunately many complicating factors enter the picture that render the technique not as good as superficially indicated: It is expensive and rarely practical for widespread application by always limited conservation personnel; sportsmen and conservation personnel are frequently much more enthusiastic about starting such a program than actually seeing it through; it may induce a dependence of the fed game upon artificial feeding and consequently leave it in a precarious position if the feeding is stopped, or even if successfully carried out may do no more than enable the wintering of breeding stocks in excess of the potential of the habitat and consequently offering no contribution toward increasing the fall game supply. These and other considerations have resulted in a generally unfavorable attitude of game management men toward artificial feeding. The attitude of personnel conducting and supervising the present study constituted no exception, and all findings have been viewed critically.

The work reported in this paper is based on two sources of data: various experiments conducted in Charlotte County, Florida, between 1948 and 1953; and reports from questionnaires sent to private individuals maintaining quail feeders at various places throughout Florida and including two areas in South Georgia. Mr. Herbert Allgood, assistant project leader of the Charlotte County Quail Investigation, a Federal Aid Project, was responsible for most of the field work in Charlotte County.

The Charlotte County work was done principally on the Cecil M. Webb Wildlife Management Area. This is a tract of 62,000 acres of cutover pine flatwoods belonging to the Florida Game and Fresh

Water Fish Commission. Most of the area is grazed and is typical of unimproved South Florida pasture lands. The dominant ground vegetation is wire grass (*Aristida stricta*).[1] Second growth Caribbean pines (*Pinus caribaea*) grow sparsely over the entire tract, except in a few areas of rarely more than three or four acres where they are sufficiently abundant to approach a closed-canopy type of forest. Frequent clumps of saw palmetto (*Serenoa repens*) provide excellent refuge cover for quail. Relatively impermeable subsoil and low surface gradient plus normally high rainfall from June through October and low rainfall during the rest of the year produce conditions alternating between flood and drought that render the quail population particularly subject to weather influences. Principal quail foods are seed of slough grass (*Scleria setacea*), fruits of dwarf wax myrtle (*Cerothamnus pumila*), acorns (*Quercus* sp.) puffball fungus (*Rhizopogon* sp.), and seed of various grasses principally of the genera *Paspalum, Panicum,* and *Digitaria.*

This study was inspired by results of the maintenance of a bobwhite quail trapping station at the home of Mr. Allgood in Punta Gorda, Florida. In February 1948 a covey of 11 birds was trapped at the station and banded. To facilitate further trapping and also to check the possible effect of artificially supplied grain on birds in the area, it was decided to keep feed at this station throughout the summer. In May and June large numbers of young quail were observed regularly using the feeder. On July 10, 1949, 88 quail were trapped at the feeder. Seven of these were banded mature birds, three of which had been trapped at this station in February. The remaining banded mature birds had been trapped at this station at some other previous time. Eight were unbanded mature birds and the remaining 73 were juveniles from 5 to 12 weeks old. The number of birds that escaped the trapping as well as the ones later observed without bands at the feeder left little doubt that more than 100 birds regularly used the feeder.

These results suggested the possibility of feeders increasing quail populations in South Florida. With this thought an experimental feeder area, where an average of 14 feeders were maintained, was established on one square mile of the Cecil M. Webb Wildlife Management Area in the spring of 1949. At the same time two private individuals, Mr. Cecil M. Webb, at that time a member of the Florida Game and Fresh Water Fish Commission, and Mr. L. C. Edwards of Dade City, Florida, became sufficiently interested when told of these results to establish feeder areas on a much larger scale—each placing

[1]Botanical nomenclature follows "Manual of Southeastern Florida" by J. K. Small.

feeders on areas of approximately 5,000 acres in Pasco County, Florida. In the fall of 1949 both of the above gentlemen expressed extreme satisfaction with the results of their first-year feeder program.

Quail regularly used the feeders on the management area, but it soon became evident that one square mile of land was inadequate to obtain accurate information as to the actual effect of the feeders on the quail population. Therefore, in the spring of 1950 the experimental feeder area was enlarged to approximately 5000 acres with an average of 80 operating feeders. This experiment had two principal objectives —to determine the effect of the feeders upon the quail population and to determine the cost of any increase that might occur. Related information such as food habits of quail on feeder areas and seasonal usage of feeders was also collected.

Information from the above experimental area has been supplemented by responses to questionnaires sent to the private individuals operating feeders under special permit from the Florida Game and Fresh Water Fish Commission. The questionnaires were designed to gather information about costs, techniques and success of private feeder programs. Thirty completed questionnaires were returned from the 88 mailed in March, 1951, and 51 from the 78 mailed in March, 1952. Twelve of the 1952 returns were from cooperators who also made returns in 1951.

TYPES OF FEEDERS

Three principal types of feeders are in common use. One of these is simply a six- or seven-gallon galvanized garbage can with slits cut near the bottom to enable birds to get at the grain in the can and with a metal apron attached to the top of the can and exending outward to shelter adequately the grain exposed by the slits. Another feeder, basically a modification of the garbage-can type, is being manufactured commercially by Scruggs Quail Feeders, Tampa, Florida. It differs from the garbage-can type principally in that it is suspended from a pipe driven into the ground. The third type consists of a four-foot-square framework of two-by-four lumber covered with a peaked galvanized metal roof with its apex approximately two feet from the ground. A metal food container properly slitted and of approximately five gallons' capacity is placed under this shelter.

After experimenting with several types of openings for quail to reach the food in the containers, it has been found that the most practical arrangement is a simple horizontal slit two inches above the ground, three or four inches long, with the metal pushed in above the slit enough to permit quail to get at the grain but not enough to allow the grain to spill out upon the ground.

Where hogs and cattle occur on feeder areas, all three types of feeders must be protected against loss of food or damage to the feeder by these animals. The garbage-can feeder must be enclosed within a hog-wire fence (normally a triangular enclosure six feet on a side) where hogs occur. A barbed-wire fence will suffice if cattle alone is the problem. The Scruggs feeder is fairly cattle-proof but must be protected from hogs in a manner similar to the one used for the garbage-can type. The shelter type feeder is also cattle-proof but must be anchored to trees or posts to prevent its being turned over or shoved about by hogs. All three feeders are reasonably weatherproof except when rainfall is accompanied by excessively high winds.

The shelter type feeder has one serious disadvantage not shared by the other feeders. This is the development of sour, moldy conditions during wet weather on heavy soils protected from sunlight by the shelter. Special attention must be given to the depth and size of the pipe supporting the Scrubbs feeders so that the feeder is rigidly suspended and free to rotate on its orbit when touched by cattle.

Approximate costs of the three types of feeders are as follows:

Garbage can type feeder:		
Feeder	$4.00	
Wire for hog fence	1.00	
Posts	.75	
Lumber for braces	.35	
Labor	2.50	
TOTAL	$8.60	per feeder installed.
Shelter type feeder:		
2 x 4 lumber	$1.35	
Metal roofing	2.00	
Barbed wire	.20	
Can for feeder	.15	
Labor	2.50	
TOTAL	$6.20	per feeder installed.
Scruggs feeders:		
8 qt. size	$5.00—FOB, Tampa, Fla.	
12 qt. size	$6.50—Shipping Wt. 13 lbs.	

Quail readily use all three types of feeders once they learn that they are a source of food. Records kept at each of the assistant project leader's visits to the management area feeders between June, 1950, and

March, 1953, showed fresh quail sign at 74.21 per cent of the visits to approximately 40 garbage-can-type feeders compared to 60.96 per cent of the visits to approximately 40 shelter-type feeders. This may, however, indicate a difference in amount of sign left at the two types of feeder rather than an actual preference.

The compilation of replies to both the 1951 and 1952 questionnaires mailed to private feeder operators showed 35 individuals using the shelter-type feeder, 20 using the garbage-can type, 8 the Scruggs feeder, and 4 using mixtures of the various types. Preferences indicated were: 30 favored the shelter type, 10 the garbage-can type and 7 the Scruggs feeder. In general, cooperators indicated a preference for the type of feeder they were using. Therefore, due to extensive advertising and publicity given the Scruggs feeder, a current questionnaire would probably show both increased usage and preference for the Scruggs feeder.

FEEDER OPERATION

Present methods of operating feeders call for the distribution of feeders at the rate of approximately 10 feeders per section of land. They should be placed near good refuge cover and near natural quail travel lanes so that they are easily accessible to the birds. The most efficient usage contemplates servicing feeders once every two or three weeks with visits at greater or lesser intervals as weather, usage by quail, and other factors demand.

Labor constitutes one of the two major items of cost in operating feeders. According to records from the management area, 50½ man days per year in 1952 were necessary to service and maintain an average of 80 feeders on the 5,000-acre feeder tract. Based on 275 work days per year (fifty 5½-day weeks) this amounted to 18.4 per cent of the assistant project leader's work time. Using 18.4 per cent of his salary as labor cost for operating 80 feeders we find an annual labor cost per feeder of $8.28. Replies from the feeder questionnaires gave an average annual labor cost per feeder of $6.25.

Many of the private feeder projects are operated as a hobby by the permittees themselves; others are operated by persons employed on private quail preserves. In many of the latter instances the duty of maintaining feeders was simply added to the patrol duties of personnel already employed.

As a general rule, feeders need to be visited once every two to three weeks, depending upon weather, the usage of feed, and other factors. The major activity in feeder operation is simply the keeping of feed in the feeders plus minor repairs to the feeders themselves.

FEED—COSTS AND TYPES

Cracked corn and poultry scratch feed were about equal with regard to usage and preference among the feeder permittees. The average annual cost of feed per feeder as reported in replies to the feeder questionnaire was $6.70.

On the management area, poultry scratch, cracked corn, and hegari have been used. Quail appear to show a slight preference for corn but the difference in cost (averaging $4.75 per hundred pounds for corn as compared to $3.00 per hundred pounds for hegari) is believed to outweigh the presumably superior nutritional qualities of the corn. The average annual cost of feed per feeder on the Management Area based on the amount of feed used over a three-year period is: Corn or poultry scratch—$14.06, hegari—$8.88.

Various other types of feed—including wheat and waste from seed and grain-processing plants have been used with some degree of success. Prepared commercial quail pellets or poultry mash have generally not proven satisfactory principally because of the necessity of frequent maintenance visits to prevent ''gumming up'' of feeders during wet weather and spoiling of feed.

Theoretically, the more nearly a balanced diet the feed in the feeders, the more the birds could depend upon the feeders and the more the feeders could be expected to influence the quail population. The question is—Would the extra expense and effort involved in attempting to feed a balanced diet be justified in terms of additional birds produced? The thinking at present is in terms of an easily handled high-quality food used as a supplement to or supplemented by natural foods that supply the necessary ingredients to provide a balanced diet. Various studies, particularly that of Michael (1951), indicate that quail instinctively seek out a balanced diet within the limitations of their environment.

USAGE OF FEEDERS

In order to determine usage of quail feeders during the hunting season, analysis was made by Mr. Robert Garrison of 157 crops taken from Mr. Webb's Pasco County feeder area in 1950-51. Visual estimate of volumetric percentages of food items in each crop was used. Results of the analysis are presented in Table 1.

In addition analyses were made of material from quail crops obtained from a cooperator with a quail feeder project in Worth County, Georgia. Individual crops were not saved by the cooperator in this case. The contents of crops taken each month were emptied into a container and over-all visual estimates were made of the percentages of the various food items in each monthly collection. Results of this

TABLE 1. PERCENTAGE OF FOOD ITEMS FOUND IN 157 CROPS FROM QUAIL TAKEN FROM CECIL M. WEBB'S QUAIL FEEDER AREA IN PASCO COUNTY, FLORIDA, DURING THE 1950-51 HUNTING SEASON

Item	Nov. 23-30	Dec. 1-15	Dec. 16-31	Jan. 1-15	Jan. 16-Feb. 6	Total
Plant Food						
Cracked Corn	79.35	90.30	88.32	93.61	97.75	86.98
Viola sp.						
Violet	1.67	3.03	.25			1.27
Sagotia triflora	.74	.30	5.50	.83		1.81
Chamaecrista sp.						
Partridge pea		.15				.03
Meibomia sp.						
Beggarweed					.42	.03
Sesban emerus						
Sesbania	.18					.63
Stillingia sp.	.09					.03
Pinus australis						
Long leaf pine	2.31	.45	.37			.98
Quercus sp.						
Acorn	1.20	6.52	.37			1.88
Panicum sp.	.09					.03
Tamala sp.						
Red bay				1.11		.13
Pinus palustris						
Slash pine	.09					.03
Green Material	.56	.45	.88	3.33	.83	.95
Feeder Material (Other than corn)	1.94	.15	.37	1.11	1.00	1.00
Cerothamnus sp.						
Wax Myrtle		.76	.13			.19
Sabal palmetto						
Cabbage palm fruits	.55					.19
Crotalaria sp.	.18	.15	.13			.13
Digitaria sp.	.18					.06
Rhizopogon sp.						
Puff ball fungus			2.00			.51
Animal Food						
Coleoptera						
Beetles	Trace	Trace	.12			.03
Lepidoptera						
Caterpillar	.09	.15				.06
Orthoptera						
Grasshopper			.75			.19
Hymenoptera						
Ants	.27	.61				.22
Bufo quercicus						
Oak toad			1.00			.25

analysis is presented in Table 2. This method does not presume to be as accurate as analysis of each individual crop but is believed to be adequate for determining the relative importance of feeder material in the diet of the birds.

Cracked corn was used in the feeders on both areas. The whole corn found in the Georgia crops is presumed to have been picked up in cornfields and is treated separately from the material obtained from feeders.

Both analyses showed the percentage of cracked corn advancing with the season. This trend confirms field observations and feed—consumption records from Charlotte County which show utilization of feeders to be inversely correlated with abundance of natural food. Familiarity with seasonal food availability permitting cessation of feeder maintenance during periods of natural food abudance will probably prove to be one method of reducing the cost of feeder operation. Several private individuals reported temporary cessation of feeder maintenance during the fall and early winter.

In Table 3 is a monthly listing of the amount of food used in the Management Area feeders from April 1950 to March 1953. In Table

TABLE 2. PERCENTAGES OF FOOD ITEMS FOUND IN CROPS FROM QUAIL TAKEN FROM W. H. FLOWERS' QUAIL FEEDER AREA IN WORTH COUNTY, GEORGIA, DURING THE 1951-52 HUNTING SEASON

Item	November %	December %	January %	February %	Total[2]
Plant Food					
Cracked Corn	tr[1]	45	30	55	32.5
Whole White Corn		5	5		2.5
Whole Yellow Corn	2		20		3.00
Ambrosia sp.					
Ragweed	10				2.5
Paspalum boscianum					
Bullgrass	10				2.5
Arachis hypogea					
Peanut	18	10	20	20	17.0
Chamaecrista sp.					
Partridge pea	3	tr	10	10	6.00
Meibomia sp.					
Beggarweed	5	tr	10	15	7.5
Pinus palustris					
Slash pine	5	tr			1.5
Lespedeza sp. (native)	tr		5		1.5
Vigna sinensis					
Cow pea	3	15	10	tr	7.0
Galactia sp.					
Milk pea		tr			tr
Pinus australis					
Longleaf pine	42	25	tr		16.5
Lespedeza straiata					
Common lespedeza		tr			tr
Trifolium sp.					
Clover leaves			tr	tr	tr
Scleria sp.					
Nut rush			tr		tr
Bradburya sp.					
Butterfly pea			tr		tr
Rhus sp.					
Sumac			tr		tr
Crotalaria sp.			tr		tr
Cerothamnus sp.					
Wax myrtle				tr	tr
Cracca sp.					
Wild sweet pea				tr	tr
Animal Food					
Homoptera					
Leaf Hopper				tr	tr
Araneida					
Spider		tr			tr
Gastropopda					
Snail	tr	tr			tr
Hemiptera					
Stink bug	tr				tr
Coleoptera					
Beetle	tr		tr	tr	tr
Orthoptera					
Grashopper	2	tr			tr
Hymenoptera					
Ants	tr			tr	tr

[1]tr.—Trace—less than one per cent
[2]Total percentage figures to nearest 0.5 of one per cent

TABLE 3. MONTHLY LISTING OF AMOUNT OF FOOD USED ON THE CHARLOTTE COUNTY FEEDER AREA WITH AN AVERAGE OF 80 FEEDERS IN OPERATION.

	1950-51 Pounds per Month	1951-52 Pounds per Month	1952-53 Pounds per Month	Total Pounds per Month
April	1,500	2,000	2,750	6,250
May	1,600	2,700	2,200	6,500
June	2,500	3,300	2,200	8,000
July	1,500	3,000	1,500	6,000
August	1,500	3,400	3,100[2]	8,000
September	1,700	1,700	3,500	6,900
October	900	1,400	2,900	5,200
November	600	1,400	2,300	4,300
December	700	1,200	1,300	3,200
January	1,100	800	0[3]	1,900
February	2,300	2,100	2,800[1]	7,200
March	3,300	900[1]	3,400	7,600
TOTAL	19,200	23,900	27,950	71,050
Total 4 Months October-January	3,300	4,800	6,500	14,600
Total 8 Months February-Sept.	15,900	19,100	21,450	56,450

[1]Switched from cracked corn and poultry scratch to Hegari
[2]Switched from Hegari to poultry scratch and cracked corn
[3]Feeders not serviced in January due to little indication of usage by quail

4 is presented the monthly usage of feeders as determined by presence of fresh quail sign at routine maintenance visits by the Assistant Project Leader. These figures are a compilation of records from one visit to all feeders each month. Due to the consumption of feed by rats, raccoons, hogs, and birds other than quail, Table 3 is not solely a reflection of utilization by quail and is not believed to be as satisfactory for this purpose as Table 4.

Immediately noticeable from both tables in the apparent seasonal variation in feeder usage, with the period from October through January showing the least amount of feed used and in 1951-52 and

TABLE 4. MONTHLY USAGE OF FEEDERS BY QUAIL ON THE CHARLOTTE COUNTY FEEDER AREA AS DETERMINED BY PRESENCE OF FRESH QUAIL SIGN AT ROUTINE MAINTENANCE VISITS TO FEEDERS.

	1950-51 Percent Usage	1951-52 Percent Usage	1952-53 Percent Usage
June	47.5	90.2	91.3
July	52.4	92.7	72.7
August	51.2	89.0	78.0
September	47.2	79.3	91.5
October	62.5	62.2	63.4
November	68.0	35.4	44.7
December	60.5	42.7	39.1
January	82.6	23.1	....[1]
February	48.7	52.4	....[1]
March	79.3	85.4	82.9
April	90.2	92.6	
May	90.2	84.1	

[1]Feeders not serviced in January due to evidence of little usage by quail. Since no feed was kept in feeders during January usage of feeders by quail at the single February visit is not recorded.

1952-1953 the least utilization of feeders by quail. The relatively high utilization of feeders by quail from October through January in the 1950-51 season is believed to be due to the extreme scarcity of the two most important Charlotte County winter quail foods—slough grass seed and wax myrtle (*Cerothamnus* sp.) fruits.

The scarcity of these foods in the winter of 1950-51 was confirmed by field observations as well as by quail food habits studies based on annual analysis of more than 500 Charlotte County quail crops. These analyses showed slough grass and wax myrtle together forming only 16.3 per cent of the winter food of quail in 1950-51 as compared to from 55.3 per cent to 62.7 per cent in the other six years for which analyses are available. Similarly quadrat studies of slough grass abundance showed an average of only 2.61 stalks per square yard in the winter of 1950-51 as compared to 10.41 in 1951-52 and 7.11 in 1952-53.

The relatively low utilization of feeders in the summer of 1950 is believed to be due partly to the fact that the feeder program had just started and birds were not taking full advantage of the feeders. Perhaps of greater significance is the probability that the quail population had not been increased at this time by the feeders to the levels existing in 1951 and 1952 and the feeders did not show the utilization induced by the consequent higher population.

Use of feeders by other animals. A number of other birds and mammals interfere with feeder operation in various ways. Protection against cattle and hogs is essential to the operation of feeders and is contemplated in their construction. Rats, raccoons, and birds other than quail are also important factors in feeder operations.

Raccoons are a particular nuisance due to their digging under and turning over feeders, pulling lids off of feeders, piling feed out upon the ground and generally playing havoc with anything that isn't securely fastened. Rats, principally cotton rats (*Sigmodon hipidus*) where abundant are capable of destroying sizable quantities of feed. Birds other than quail, such as mourning doves and blackbirds, also consume large quantities of feed at times. Replies to the questionnaires rated birds other than quail as offering the most interference with feeder programs. Rats were rated second and raccoons third. The latter two animals can be fairly easily controlled if their damage becomes intolerable. Grain-eating birds present a different problem, and as a rule losses attributable to them must simply be charged off as an expected expense.

There is no evidence that properly situated feeders render quail particularly vulnerable to predation, although a number of replies to questionnaires credited hawks and other predators with interfering with feeder operations. One very definite problem, however, is the attractiveness of feeders to rattlesnakes—presumably because of the concentration of rats around them. The presence of these reptiles presents a definite hazard to careless feeder attendants as well as to bird dogs attracted to the feeders by the scent of quail.

RESTOCKING

As would be expected, many quail feeder operators consider the release of quail on feeder areas as an essential part of the over-all program. In some cases such releases may be worthwhile if consideration is taken of the fact that the quail productive potential of a given area is presumably suddenly raised by the addition of feeders and the breeding stock present might not be able to raise the population sufficiently in one year to realize the full capabilities of the improved habitat. Such releases may also be of value from the standpoint of arousing and holding the interest of the private operator who frequently thinks in terms of "planting" quail and receives a great deal of enjoyment from handling and releasing the birds. In the matter of stocking, the Florida Commission takes the position of co-operating with private individuals wishing to release birds without advocating such releases except possibly in the first year and advising against the use of pen-reared birds.

Evidence from a study conducted by the Commission (Gainey, 1951) indicated that the use of pen-reared birds on feeders was of no value, if not actually detrimental.

A number of cooperators restocked feeder areas and some of these expressed the opinion that such restocking was highly beneficial. The total number of birds restocked, however, was negligible as compared to the birds on feeder areas when feeder programs were begun.

INFLUENCE OF FEEDERS ON THE QUAIL POPULATION

Beginning in the fall of 1950, a fall and spring census has been conducted on the Charlotte County feeder area. This census is conducted by running bird dogs along compass lines that follow established courses used at each census. From two to four dogs are run at one time with the observer afoot. Attempts are made to run those dogs together in a manner that will give the most complete coverage of the census course. A record is kept of the number of birds each time quail are found and the distance of each find from the compass line being followed by the observer. When the census is completed, the average of all distances of the finds from the compass line is determined. This average is doubled to give the width of the strip presumably covered by the dogs. The acreage of this strip is then calculated from the width of the strip and the length of the census course. The number of birds found within the strip is then calculated and divided into the acreage to give a figure for acres per bird.

This figure is obviously conservative since it does not take into account the birds that are bound to be missed by even the best dogs. There are other errors in the techniques which leave certain of the figures open to question. Nevertheless, inasmuch as the principal use of the census figures in the present report is for comparison between two areas to which such census errors as exist are in general equally applicable, the present treatment is considered adequate for the purposes of this report.

There is no substantial evidence to indicate that the presence of feeders appreciably affects the vulnerability of quail to being found by dogs in the type of census utilized in this study. Such evidence that has been found indicates that any difference that might exist would tend to result in missing a greater proportion of the birds on feeder areas than on areas with no feeders. The easy availability of feed in the feeders removes the necessity of quail moving extensively in foraging activities, probably results in fewer trails and less scent and thus renders the birds less likely to be found by dogs.

Actual hunting differs somewhat from census work since in hunting the effort is devoted to locating birds wherever they may be, whereas in census work the effort is devoted to covering straight courses established at random with no regard to feeder locations or other habitat features. In answer to the inquiry as to the effect of feeders on hunting, 25 replies to questionnaires indicated the cooperator believed feeders made birds easier to find, 7 indicated the cooperator believed feeders made birds more difficult to find, and 38 indicated the cooperators believed that feeders had no appreciable effect on hunting. As a general rule, it is believed that the necessity for relatively little quail movement on feeder areas and the influence of this situation on vulnerability of birds to dogs will be fairly well balanced by the fact that the feeders tend to localize birds in their immediate vicinity and thus render them more easily found by hunters.

In Table 5 is presented a comparison of quail densities on and off the experimental feeder area on the Cecil M. Webb Wildlife Management Area. The figures for the feeder area represent three runnings of the same eight census courses in the 1951-52 and 1952-53 census, one running in the spring of 1951 and one and one-half runnings in the fall of 1950. All runnings of courses on either the feeder area or the check area during any particular census are totalled so as to give a composite figure for all census data from the area being censused. The amount of census on the feeder area was tripled when it became evident that less than 50 miles of census probably did not constitute an adequate sample of the quail population of an area.

The figures for the check area consider all census run on the 38,000 acres of the management area surrounding the feeder tract.

Except for 1951-52 the census records in Table 5 show a density of birds on the feeder area approximately twice that of the check area. These figures are supported by general field observations which indicated an exceptional abundance of quail on the feeder area and are believed to be indicative of the actual situation existing.

The 1951-52 situation is believed to be due to a movement of birds from the feeder area, possibly as a result of the exceptionally heavy slough grass crop. Table 4 supports this theory since utilization of feeders by quail is less during the October-January period in 1951-52 than in any other like period. Similarly, but less significant, is the fact that the amount of feed used in the October-December period in the 1951-52 season is appreciably less than in the same period in the 1952-53 season.

The fact that the census figures showed a smaller increase on the feeder area (from 6.73 acres per bird to 5.55 acres per bird) than on the check area (from 11.95 acres per bird to 7.54 acres per bird) from 1950 to 1951 may have reflected a movement from the feeder area or may have reflected an approach to saturation point in the quail

TABLE 5. COMPARISON OF QUAIL DENSITIES ON AND OFF A QUAIL FEEDER AREA IN CHARLOTTE COUNTY, FLORIDA

	Hours	Miles Covered	Birds Found	Average Birds per Find	Birds per Mile	Birds per Hour	Acres per Bird
			1950-51 Census October 5 to November 20, 1950				
Feeder Area	15.10	32.25	344	11.9	10.7	22.8	6.73
Check Area	32.23	78.00	399	11.1	5.1	12.4	11.95
			February 14 to March 2, 1951				
Feeder Area	10.12	21.25	168	9.9	7.9	16.6	10.32
Check Area	19.5	47.0	155	8.6	3.3	8.6	39.4
			1951-52 Census October 9 to October 30, 1951				
Feeder Area	24.95	53.50	582	12.7	10.92	23.32	5.55
Check Area	23.31	53.74	391	11.8	7.27	16.77	7.54
			February 15 to March 6, 1952				
Feeder Area	22.63	53.75	222	7.5	4.13	9.81	16.58
Check Area	21.23	51.75	175	8.2	3.38	8.24	17.80
			1952-53 Census Octoger 7 to November 16, 1952				
Feeder Area	27.61	57.50	673	11.0	11.70	24.37	4.66
Check Area	30.34	73.00	433	10.8	5.93	14.27	9.89
			February 21 to March 30, 1953				
Feeder Area	22.05	57.25	170	3.5	2.96	7.71	14.23
Check Area	19.85	53.75	135	6.5	2.51	6.80	28.81

population on the feeder area. However, the 1952 fall census shows the quail population continuing to increase on the feeder area in spite of a decrease on the check area.

The census figures in Table 5 are of particular interest in that they show the quail populations on and off the feeder area becoming more nearly equal as the winter advanced in 1951-52—presumably because the heavy slough grass crop more nearly equalized the food supply on and off the feeder area. In 1950-51, on the other hand, the superiority of the feeder area increased as the winter advanced—presumably because the scarcity of slough grass and wax myrtle attracted birds to the feeder area. Both of these changes occurred when the check area was subjected to heavy hunting pressure and the feeder area was protected from hunting. These changes plus the evidence that in 1952-53 the relative density of birds on the two areas remained practically the same throughout the winter indicates little influence of hunting on quail movement.

A possible criticism of the comparison of the feeder and check areas lies in the fact that the check area was hunted but the feeder area was not. Several points brought out by the study—particularly the increase on the feeder area the first year when neither area was hunted and the apparent free movement of birds between the two areas, indicate that this is probably an unimportant consideration. Also there is ever-increasing evidence that moderate shooting is relatively insignificant as a factor determining quail numbers. Even if the two areas are not exactly comparable because of difference in hunting, the fact remains that the concentration of birds on the feeder area is considerably heavier than has ever been recorded for the same type of land in Charlotte County even when protected from hunting.

The thought has been advanced that perhaps the feeders only pull quail in from surrounding areas, do not actually increase quail populations, and that thus the fall and spring quail census of the feeder area is sampling a concentration of birds baited to the feeder area. Quite the contrary seems to be the case since both Table 3 and 4 show a reduction in utilization of feeders during the time of year the census is run. In all probability the feeder area census actually samples a population reduced somewhat by movement of birds from the feeder area during the normal fall abundance of food.

The feeder questionnaires included several questions relative to the effect of feeders on quail populations on private feeder areas. The answers to these questions are tabulated in Table 6. Only those replies giving answers to all of the related questions could be used in

TABLE 6. QUAIL POPULATION CHANGES ON PRIVATE FEEDER AREAS AS REPORTED IN REPLIES TO QUESTIONNAIRS.

	No. Quail Present When Project Began	No. Restocked	No. Co-operators Restocking	No. Quail Present Following Fall	Per Cent increase	No. Quail Bagged
First Reporters—One breeding season covered						
1951 Questionnaire 19 Replies	3415	294 Wild-trapped 66 pen-reared	8	6925	102.7	2,744
1952 Questionnaire 11 Replies	5180	48 Wild-trapped	2	6850	32.2	Not reported
First Reporters—Two breeding seasons covered						
1952 Questionnaire 3 Replies	710	20 Pen-reared	1	1980[1]	178.9[1]	550
Second Reporters—The 1951 questionnaire reports the first year's results, the 1952 questionnaire the second year's results of the same eleven cooperators						
1951 Questionnaire 11 Replies	3930	185 Wild-trapped 50 Pen-reared	4	6290	60.0	1,962
1952 Questionnaire 11 Replies		156 Wild-trapped 30 Pen-reared	4	11030	75.3[2]	2,643

[1]This represents the fall population after the feeders had been in for two breeding seasons.
[2]This represents the increase from fall of 1951 to fall of 1952, the increase from start of project, two breeding seasons, is 180.7%.

tabulating the population information. In this table, distinction is made between those cooperators reporting only once (First Reporters) and those reporting twice (Second Reporters) as well as those cooperators reporting for the first time after their feeders had been installed for two breeding seasons.

The figures in Table 6 are based on estimates made by the cooperators and are undoubtedly of variable accuracy. However, certain of them, based on carefully kept records of coveys found during the hunting season, are probably a accurate as most estimates of quail populations. Nevertheless, in evaluating these figures one must consider the possibility that the setting up of a feeder program influenced the cooperator's *estimate* of the population as well as the population itself. This could have taken place—for example—as the result of the cooperator being in the field more and consequently observing more birds; as a result of the birds already on the area being more conspicuous because of their usage of the feeders; or as a result of the cooperator's subconscious desire to attribute success to his feeder program. Regardless of the probable inaccuracies in numerical details of the foregoing data, there is little reason to doubt that they do show a substantial increase in quail as a result of using feeders.

Various replies were received to the question, "In general, has your feeder program been successful?" Replies of "First Reporters" on both questionnaires were as follows 22 cooperators reported their program highly successful; 22, fairly successful; 1, too time-consuming or expensive to continue; 3, a failure; and 3 stated their program had not been carried on long enough to form an opinion. The replies from the "Second Reporters" are probably the most significant of the various types of replies since they reflect the opinions of those persons with the longest and presumably the best records of their feeder programs. Of the 11 "Second Reporters," 4 reported their program highly successful and 7 fairly successful on the 1951 questionnaire; 5, highly successful; and 6, fairly successful on the 1952 questionnaire. The one person reporting a failure with his feeder program on the 1951 questionnaire stated that of 20 birds shot on the feeder area, only two contained corn. He also remarked that feed was not kept in the feeder during the rainy season, which is the summer breeding season in south Florida—the location of his feeder area. Since our observations indicate that the primary importance of the feeders lies in increasing quail reproduction, the fact that feed was not kept in feeders during the reproductive period might very well account for this failure. One of the two persons reporting a failure on the 1952 questionnaire stated that he was unable to find as many birds since installing the feeders as previously even though ranch personnel reported frequently seeing birds at the feeders. This man plans to continue the experiment for two more years. The other cooperator reporting a failure on the 1952 questionnaire stated that birds used feeders only at periodic intervals, that he has been unable to keep hogs from his feeders with any practical means, and that he got no return whatsoever from 20 pairs of pen-reared birds released at feeders on his 300-acre feeder area.

Data from the questionnaires are undoubtedly biased because of the probability that persons experiencing success with the feeders will be more likely to reply to the questionnaires. Nevertheless, there remains the simple and impressive fact that a number of private individuals continue to maintain feeder areas at considerable personal expense, harvest good crops of quail from these areas, and are convinced that their money is well spent.

SUMMARY

Since February 1948 studies have been conducted of the use of artificial feeders as a quail management tool. These studies have con-

sisted of two principal phases—operation by project personnel of experimental feeders on the Cecil M. Webb Wildlife Management Area and collection of data from private quail feeder operations.

Three principal types of feeders—garbage-can, shelter, and Scruggs—have been used successfully with quail.

Various type of feed—principally poultry scratch, cracked corn, and hegari—are used in feeders. Hegari, or other grain sorghum, is the most economical of the commonly available grains and appears to be adequate for use in quail feeders.

The average annual labor and feed cost of operating quail feeders as determined by the Charlotte Wildlife Management Area studies is $17.16 per feeder when hegari is used, $22.34 per feeder when cracked corn or poultry scratch is used. The labor and feed cost, as estimated by feeder permittees, is $12.95 per feeder.

Substantial increases in quail as a result of feeders were found on the Management Area and were reported by quail feeder permittees. Based on an arithmetic average of the three years acre-per-bird fall and spring census figures in Table 5, the density of quail on the feeder area was 100.66 per cent higher than on the check area. Based on an arithmetic average of all classes of permittee reports, the average increase in quail on feeder areas after one breeding season was 64.96 per cent, after two breeding seasons 179.80 per cent.

At an arithmetic average fall density of one bird per 5.64 acres on the feeder area as compared to one bird per 9.79 acres on the check area the fall population averaged 886 birds on the 5000 acre feeder area as compared to 511 birds per 5000 acres of the check area or a superiority of 375 birds for the feeder area. Using the stated labor and feed costs for the Charlotte Area, the 375-bird increase cost $1,372.80 or $3.66 per bird if hegari is used; $1,787.20 or $4.77 per bird if cracked corn or poultry scratch is used.

The above are maximum costs based on a conservative estimate of the quail population and actual expenditures—including more expensive labor than necessary. If we assume that 50 per cent of the birds are missed in the census, labor is calculated at $2,400.00 per year instead of $3,600.00, and hegari is used altogether, then the total annual cost of the 750-bird increase is $1,152.19 or $1.54 per bird. Although this latter figure is theoretical, it is probably much nearer the actual cost of increasing quail by means of feeders in grazed South Florida flatwoods.

Questionnaire replies from the seven permittees reporting twice who started feeders in 1950 and had feeder operations of suitable size were tabulated for information similar to the above. Data from these permittees is considered to be the most reliable of the several different classes available. These tabulations showed 214 feeders maintained on 31,480 acres at an average cost per feeder of $7.63 for feed and $3.93 for labor. The number of quail was reported to have increased in one breeding season from 2425 to 3720. This constitutes an increase of 1295 birds at a total labor-feed cost of $2,475.00 or $1.91 per bird.

The results of the feeder studies to date indicate that:

1. Automatic feeders constitute a practical management tool for increasing quail populations where food is the limiting factor and soil, weather, and land uses are not suitable for food planting. They are probably of most value on and are most applicable to areas subject to heavy grazing.

2. With present techniques the cost of feeder operation is prohibitive for widespread use by state game departments to furnish public quail hunting at existing hunting permit rates.

3. The principal use of feeders at present lies in private or club projects and that the cost of birds produced by feeders compares favorably with that of birds produced by food planting, patch farming, or other intensive quail management methods.

4. Because of the simplicity of feeder operation and its appeal to the average sportsman, feeders are of particular value to hunters of moderate means willing to devote a reasonable amount of money and effort to providing themselves with good quail shooting.

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DISCUSSION

MR. RALPH H. ALLEN, JR. (Alabama Department of Conservation, Montgomery, Alabama): In our state there are a lot of sportsmen who are beginning to regard the quail feeders as a panacea and for those who see it that way I don't know whether he told quite enough about the type of cover on his area. We fed on one square mile and had fewer quail at the end of two years than before. We have little habitat in that area, so we are one of those who have had negative results. We are continuing this because of the fact so many people regard it as a panacea.

MR. FRYE: That panacea problem is certainly one that we ran into. It is no panacea. I think it is a useful tool under certain conditions.

As to the cover, I am quite confident that the feeders are of value only in places where the food supply is low. Where the feeders have been of most value is where we have a good distribution of cover kept in good shape by grazing. It is not too dense and the thing that is lacking in those situations is a readily available supply of high-quality food. Where that is the case, watch your quail population rise.

MR. ROBERT MCCABE (University of Wisconsin, Madison, Wisconsin): I would like to ask Earl why the feeding efforts didn't tend to concentrate the birds of a thinly populated area rather than increase the population?

MR. FRYE: I believe we have areas of such size that it is actually increasing the population rather than just merely collecting the birds. You find that the birds very frequently leave the feeders and even leave the feeder area during the period of abundance, but they come back and use them when they need them.

INFLUENCE OF CALCIUM ON THE DISTRIBUTION OF THE PHEASANT IN NORTH AMERICA

FRED H. DALE

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Nearly 25 years ago, Aldo Leopold (1931) suggested that nutrition might be a factor controlling distribution of the pheasant in the Lake States. He was impressed with the apparent relationship of successful establishment of the species to areas glaciated by the Wisconsin ice sheet. He hesitated, however, to suggest this as a clear-cut case of cause and effect because of some exceptions. Nevertheless, he referred to the hypothesis that "some plant growing on these soils, or some substance, such as kind of lime or gravel, contained in them, was necessary to the welfare and breeding vigor of exotics in this region."

McCann (1939) gave factual support for this point of view, when he demonstrated that "glacial gravel" given as grit contributed to the welfare of pheasants. Quartz was found to be unsatisfactory for grit on the diet tested. Unfortunately, McCann did not report on the diet used, nor did he make an analysis of the gravel. Nevertheless, this study has significance in providing a possible explanation for the unusual distribution of the pheasant in midwestern states.

Many biologists have not accepted the "glaciation hypothesis" for several reasons. Most important of these have been reluctance to consider that a single factor would control the distribution of a species, and the fact that other species succeed in areas unsuitable for the pheasant. The first reason does not apply, since Leopold proposed the glaciation theory to account for failure of the pheasant in areas that appeared from all known criteria to be suitable range. He did not suggest that glaciation alone created suitable pheasant habitat.

The second reason appears to have more validity. To rule out the question raised, it is necessary to demonstrate either that the pheasant has a higher requirement for some factor, or that the pheasant's habits are such as to make the essential factor less available to it than to other species.

A research assignment completed at the Patuxent Research Refuge in 1953 (Dale, 1954), strengthens the glaciation hypothesis. The results suggest that availability of calcium may be the limiting factor in many areas. Furthermore, they indicate why other species may not react in the same manner as the pheasant to deficiency of calcium in the soil. Diets believed comparable to that of pheasants in a natural environment were inadequate for reproduction, but this deficiency was corrected by a calcium supplement. Pheasants deprived of the supplement failed to produce a normal quota of eggs, and hatchability of the few that were produced was low.

There is no reason to believe that the pheasant's requirement for calcium is unusually high. All species utilize this element in metabolism, and vertebrates have a special need for it in the building of a skeleton. Avian females have an additional requirement of calcium for the production of eggs. This fact is well known to poultry breeders, who provide oyster shells to laying hens as a calcium supplement. Although there may be differences in the ability of animals to absorb calcium from the intestinal tract, the total requirement as a percentage of the diet probably is about the same for the different wild birds.

The level of calcium required by an animal depends in part on the balance of other items in the diet. Protein, phosphorus, and vitamin D are known to influence need, rate of absorption, and efficiency with which calcium is utilized. Calcium requirements of wild pheasants are not known, and the most readily available approach to determining these requirements is by experiments on penned birds. Studies of this type by DeWitt and Derby (unpublished) indicate that 0.5 per cent calcium in the diet is about minimum for reproduction. Although these studies were made under artificial conditions, where energy requirements and rates of food consumption may differ from those in natural habitats, the results indicate that pheasants fed grain diets require approximately 250 milligrams of calcium per day.

There is reason to believe that this level is not attained by the wild pheasant without calcareous gravel or other supplement. Of all North American game birds, the pheasant is most likely to fail to meet its calcium requirement from nutrient sources. From 50 to 75 per cent, or even more, of its diet is made up of cereal grains, with corn providing the major part. No other game bird, except possibly the Hungarian partridge, is dependent to this extent upon cereal grains which are notably low in calcium. Corn has only about 0.01 per cent, wheat about 0.05 per cent, and barley and oats 0.09 per cent. Thus, the pheasant gets but a small part of its calcium needs from a half to three-fourths of its food. In order for it to obtain the estimated 0.5 per cent minimum requirement from food sources, the non-cereal part of the diet would have to have an average calcium level of from 1 to 2 per cent.

A review of food-habits studies will show that, although our knowledge of the pheasant's natural diet is incomplete, the prospects of this being accomplished are slight. Most food-habits studies result in only a superficial appraisal of the relative importance of major items. From such studies we are able to estimate the relative importance of various food items. However, we do not know proportions by weight, nor do we always know the trace items in the diet.

Dalke (1937) made a valuable contribution to our knowledge of pheasant food habits by the use of precise analytical techniques. He oven-dried crop contents, and weighed them on analytical balances to compute percentages. The nutritionists can use these results directly in computing the calcium level of the diet. Trautman (1952) also used weight rather than volume, although his materials were air-dried for a minimum of six days before analysis.

If we consider these two studies as adequate for estimate, then it is clear that the pheasant does not obtain sufficient calcium from its natural food, exclusive of grit. The annual diets indicated by them are as follows:

Item	Michigan (Dalke)	South Dakota (Trautman)
Cultivated grains	73.87%	81.7%
Wild seeds	12.17	7.1
Fruits and nuts	7.48	....
Grass and leaves	3.24	4.5
Animal matter	3.24	5.4

Exact chemical analyses have not been made for all these items, but a liberal estimate for calcium levels, based on Ewing (1951) and King and McClure (1944) is taken as: Cultivated grains, 0.05 per cent; wild seeds, fruits, and nuts, 0.5 per cent; grass and leaves, 1.0 per cent; animal matter, 2 per cent. From these estimates, it appears that the calcium level of the entire diet would be 0.227 per cent for the Michigan pheasants and 0.229 for the South Dakota birds.

It is apparent that we are not likely to learn the exact natural diet of the pheasant. Techniques used by Dalke and Trautman are too time-consuming to be used except in special studies, and even so, they have some inescapable weaknesses. The crop analysis may be made exactly, and yet it may be unreliable because of differential rates of passage of food from crop to gizzard. Some items may be held longer than others, and the sample would thus be biased. There is an additional problem in recognizing minor items that may not be held long or may be dissolved before leaving the crop.

Studies at Patuxent, in which pheasants from wire-floored pens on a diet deficient in vitamin B_{12} were placed in pens on the ground, indicated that some factor was obtained from .the soil, or from living organisms in the soil. The ground was worked over by the pheasants until it had the appearance of having been lightly cultivated. Whatever items are obtained in this manner are not indicated in food-habits studies.

There is no apparent reason to believe that results of either nutrition or food-habits studies are far wrong, although we should recognize there is a possibility of errors. It seems doubtful that any limitation inherent in these studies would account for the apparent deficiency of about half the calcium requirement as indicated.

Both McCann's (*op. cit.*) findings and those from the research reported here indicate that calcareous grit serves as a supplement to the calcium provided by the natural diet. This assumption is strengthened by findings of both Dalke (1938) and Trautman (*op. cit.*) that consumption of grit increases just before egg production. However, from the distribution of the pheasant in some western ranges, it seems that where the calcium level in the soil is high, the bird may meet its needs without calcareous grit. Whether this is accomplished by the increased calcium content of foods produced on these soils or by ingestion of the calcium-rich soil itself is not known.

Important though this element may be in the welfare of the pheasant, the amount required is small. From findings of nutrition studies at Patuxent, it appears that the quantity of calcium needed is about 250 milligrams per day. About half this amount would be provided in the diet, exclusive of soil or grit. The additional calcium could be provided by no more than a half gram of limestone. Where limestone is not available the calcium might be obtained from ingestion of soil. This could be accomplished with no more than 5 or 6 grams of soil from Walworth County, South Dakota, within good pheasant range, where according to Holmes and Hearn (1942) surface soils contain about 2.2 per cent calcium. In contrast, Cecil loam from Maryland, where the pheasant has failed to become established, has a calcium level of only about 0.05 per cent (Anderson, *et al.* 1942). In order to obtain 125 milligrams of calcium from this soil the bird would have to ingest about 250 grams daily.

Calcium availability of soils is not known for many areas. We can estimate this factor for most soils if we know the parent materials, amount of rainfall, age of the soil, glacial history, and method of accumulation. In general, soils derived from limestone may have more calcium than those from igneous rock, although in areas of heavy rainfall, even these soils may have lost all calcium from the surface by leaching. Western soils are almost all rich in lime, because of the deposition of this and other minerals from water evaporating at the surface of the ground. To the east of the lime line, however, which runs north and south through eastern Nebraska, soils are variable in the amount of calcium. Most areas within the boundaries of the Wisconsin ice sheet have fair amounts, but there are a few exceptions.

Despite weaknesses in available data, it seems clear that the pheasant has a narrow margin of safety in meeting its calcium requirement. It also seems clear that this situation is a natural result of the pheasant's heavy utilization of cereal grains. Weed seeds and mast, which have a higher calcium level, and foliage, especially alfalfa, tend to increase the supply of calcium in the diet. More extensive use of these foods may help to explain the ability of the bobwhite to exist in areas where the pheasant can not survive.

In the eastern half of the United States, the major areas with adequate calcium include northwestern Iowa, southeastern Wisconsin, northwestern Ohio, southeastern Michigan, and western and southeastern Pennsylvania. These areas include the major pheasant centers of the eastern half of the country. Areas poor in calcium and also unproductive of pheasants include northern and southwestern Wisconsin, southern Iowa, southeastern Ohio, northern and southwestern Michigan and central Pennsylvania. Thus the correlation between abundance of pheasants and availability of calcium is clear when large areas are considered. We need, however, to study the availability of calcium in intermediate areas.

We do not mean to suggest that calcium is the only factor that influences distribution of the pheasant. Yeatter (1950) has demonstrated that high summer temperatures play a part in lowering hatchability of pheasant eggs. There is a possibility, however, that calcium level may influence this condition, since the thickness of eggshells depends in part upon the calcium level of the diet. Other limiting factors, of course, include cover and food patterns.

The role of calcium in the diet of the pheasant gives a basis for evaluating certain crops as to their effects on the species. Alfalfa, for example, has been considered as detrimental to pheasants, largely because of heavy mortality in alfalfa fields during mowing operations. Some biologists have contended, however, that the large number of pheasants that occur in most alfalfa-producing areas can be taken as evidence that this crop must make some special contribution to the welfare of the bird.

Alfalfa meal is rich in calcium, the average composition of this element being about 1.7 per cent. Nevertheless, this figure is based on an analysis of dry material, with a moisture content of about 7 per cent. Alfalfa in the field has a moisture content of about 75 per cent; so the calcium level of the succulent plant can hardly be higher than about 0.43 per cent. Thus, although alfalfa is far superior to corn in its calcium level, the pheasant can not balance its calcium requirement from amounts eaten. Like weed seeds, alfalfa is superior to grains as a source of calcium, but the bird would need a richer source to complete its requirements.

Another good source of calcium is the soybean. This plant may also help the pheasant to balance its calcium needs; yet the succulent nature of the plant makes it considerably lower as a natural source than might be expected from analysis of the dried soybean-oil meal. Those plants that are good sources of calcium generally grow best in calcium-rich soils. It may well be that the calcium content of the soil, rather than that of the alfalfa or soybean, is a potent factor in determining pheasant population density in alfalfa or soybean producing areas.

Corn, as we have seen earlier, is an important pheasant food. Yet this item, although valuable as a source of Vitamin A precursor and as a high energy food, is of low value as a source of calcium. The pheasant can subsist on a high corn diet only where it can balance its calcium requirement through a rich supplement. In the heart of the Corn Belt, the pheasant may not be able to accomplish this, and it may well be that this factor explains the low populations of pheasants in some heavy corn-producing areas.

The foregoing research on calcium requirements of the pheasant can not be applied directly in pheasant management. The results, however, raise the basic question as to the feasibility of improving pheasant habitat by increasing the calcium availability of the soil in areas now deficient in this mineral. Such follow-up research might well yield results of importance in pheasant management. It is to be hoped that some of the states will be in a position to undertake such experimental work.

There are some evident precautions that should be considered in this kind of research. The experimental area should be one in which known major needs of the pheasant are satisfied, but one deficient in calcium. Such areas exist in all states east of the lime line. Careful consideration should be given to the best method of making calcium available. Probably grit-sized limestone could be spread along fencerows, or in other places where it will not be plowed under. Details, of course, would have to be worked out to fit the local situation.

Cost of this kind of management might be high. Nevertheless, if it could be done successfully in some areas, it might be no more expensive than many other improvement procedures currently used in many states. In any event, through a segment of intensive research on pheasant nutrition, some new opportunities for experimental management of potential pheasant habitat have been created. Through such indirect channels the results of fundamental research often contribute to progress in practical operations.

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DISCUSSION

DR. SOWLS: I would like to ask what difference is there in the calcium in the plant that accrues to the limestone? Does the bird accrue the crude limestone in the same way as he would the calcium from the plant?

DR. DALE: Anything I could tell you on that would be a guess. I know they can assimilate the limestone from the grit. However, whether the same element is taken in from the plant, I don't know. That would be just a guess.

MR. FRED H. WAGNER (Wisconsin Conservation Department, Madison, Wisconsin): Do you know what the calcium content of the Nebraska sandhills is, Mr. Dale?

DR. DALE: No, but Mr. Mohler might.

DISCUSSION LEADER MOHLER: I am sorry, I can't say.

MR. WAGNER: Do you know if it is deficient?

MR. MOHLER: It is low, but I can't give the quantity.

MR. WAGNER: Isn't it true that the typical calcium areas you have mentioned are influenced by the amount of rainfall and so forth?

DR. DALE: I am not sure I understand your question. About all western areas have the same amount of calcium in the soil. I am not sure I get the significance of your question.

MR. WAGNER: I think generally in order to have calcium in the soil we have to have moderate or low precipitation and, of course, the whole complex goes into the rainfall.

DR. DALE: Except in your glaciated areas. I think you will find, in most places, glacial gravel available. Many soils are derived from limestone, and there is less limestone in soil. There is less in the western part of the country, it is true; but your source of calcium, in the eastern part of the country at least, probably is not from the soil itself, but from limestone rock or a certain amount of calcium in the rock. I would like to comment on your first question, however. The pheasant population of the sandhills, I believe, differs in that its diet is not highly cultivated grains. If the pheasant eats weed seeds, he would probably get an adequate calcium level without any other source.

MR. JAMES W. KIMBALL (Fish and Wildlife Service, Minneapolis, Minnesota): Mr. Dale, about five years ago I conducted an experiment somewhat similar to yours in Southeastern Minnesota in the non-glaciated area, did a lot of testing of bones for calcium phosphate and so forth. But, at the time I left there and had to drop the experiment, it seemed quite possible that the difficulty was in the matter of production. That is, all of the young pheasants were apparently early hatchers. I could locate no young birds who might have come from renesting. I wondered if you had picked up anything along that line that would indicate that perhaps through the basis of deficiency of calcium, there could be only one nesting. That would account for low pheasant populations, knowing how much they depend on renesting.

It may be quite possible to use calcium as a management tool. We concentrate on this in the wintertime. They move long distances to winter cover and perhaps winter and early spring is when they are in most need of the calcium for the production of eggs. But, I wonder if you found anything regarding the number of eggs laid? Is it possible they would lay only one clutch and not be able to lay any more?

DR. DALE: I think certainly that is possible. We know in poultry production there is a direct relationship between the number of eggs produced in the year and the calcium level. Some poultry men go as high as 4 and 5 per cent calcium in the diet and get 300 or 400 eggs a year. The pheasant is estimated at 30 eggs per year. Our birds did not produce that many. There could be a direct relationship, I think, if the calcium is low; even on a sub-minimum level of calcium, the bird would produce a few eggs, but they probably wouldn't hatch as well as they should.

THE UTILIZATION OF RECLAIMED COAL STRIPLANDS FOR THE PRODUCTION OF WILDLIFE

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The large-scale mining of coal by the open pit method is practiced chiefly in the Midwest and Central United States. This method of mining began during the middle of the nineteenth century in the Midwest but received great impetus with the outbreak of World Wars I and II. Since 1915 when stripmining produced an estimated 140,000 tons of coal, the industry has grown continuously until 1952 when 21,683,887 tons were produced (Annual Coal and Non-Metallic Mineral Report for 1952). Production by stripmining now represents about 60 per cent of all coal produced in Ohio.

The topography of the land resulting from stripmining is one of a series of ridges and ravines with relatively steep, short slopes, or one of gently rolling to undulating grades. The latter condition generally is present in states such as Ohio where legislative action requires the operator to reclaim the affected area by grading and planting.[1] In Ohio, as of Dec., 1952, there were approximately 77,625 acres of coal striplands located in 28 counties, largely in the unglaciated southeastern section. Of the total area affected approximately 52,303 acres had been reclaimed while the remainder, largely pre-law banks, supported volunteer vegetation in various stages of succession. Approximately 50 per cent of the coal striplands in Ohio are located in Harrison, Jefferson and Belmont Counties.

The data presented in this paper were obtained mainly in Ohio during the period 1946-1952, while some material was also obtained in Indiana and Illinois during the summer of 1949. The majority of the information presented deals with reclamation projects initiated on prelaw banks since the vegetation was in a more advanced stage of development. The topography consisted of the familiar ridges and ravines with slopes ranging from 5 to 55 degrees and up to 80 feet in length. The objectives of the study were (1) to determine the wildlife populations inhabiting reclaimed coal striplands in comparison to the populations on adjacent cropland, abandoned farmland and forestland, (2) to determine the value of stripmine lakes and ponds for fish and other forms of animal life, and (3) to evaluate current reclamation practices and the plant species used as to their value in producing wildlife habitat.

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[1]The Ohio General Assembly passed stripmine control legislation which became effective in 1949.

STUDY METHODS

To determine the wildlife populations present under the different types of land use, a 1,200-acre study area was selected in east-central Ohio consisting of reclaimed coal stripland, cropland, abandoned farmland and forestland. Various census methods were used, including live-trapping, direct observations and checking hunters in the field during hunting season.

An intensive study of 82 artificial forest and shrub plantations, legume-grass seedings and volunteer herbaceous-woody coverts was made on land that had been stripped for the underlying coal. Of the areas studied, 69 were in Ohio, 6 in Indiana and 7 in Illinois. A total of 13 stripmine lakes were studied in Ohio and 8 in the latter two states. Each of the 82 plantations and seedings were surveyed to determine survival percentages of trees, percentage of spoil surface covering in seedings, spoil pH, volunteer plant species present and amount of leaf litter. One or more belt transects, 12 feet in width and the length of the plantation or seeding was laid out depending upon the size of the unit while quadrats were also used on occasion. The age of each unit was determined by increment borings or questioning the landowner.

The aquatic areas were studied for the pH of the water and of the watershed material, depth of the lake, and plant and animal species present. Test-netting was done in some lakes to determine the size and species of fish.

RECLAMATION PHASES

Due to the varied geological formations in the areas stripped for coal in Ohio, the pH of the spoil material varied considerably. Tests for pH on the stripland spoil material generally ranged from 3.5 to 8.0 with some extremes beyond each of these. The majority of the spoils tested, however, had an acid pH range from 4.5 to 6.5. The spoil material in Ohio consisted of 47 per cent acid, 42 per cent calcareous and 11 per cent a patch-wise mixture of the two (Limstrom, 1948).

The species of plants used in reclaiming the striplands depend largely on the capability of the spoil material and the desires of the landowner or operator as to the future use of the land. The larger seedings of legumes and grasses were located in the Harrison-Jefferson County area on spoils containing a considerable amount of limestone, while forest plantings were located over a much wider range and chiefly on acid spoils. Although a multiple-use program is applied on the majority of the areas in Ohio, including forestry, grazing, wildlife, recreation and horticulture, the first two have been of major importance. Since 1950 an intensive effort has been made to develop wildlife and recreation plans along with the forestry and grazing phases. Some stripped areas in Ohio were being planned and reclaimed specifically for wildlife and recreation. Lakes and ponds were being established wherever possible and stocked with fish. Facilities including boat docks, diving platforms, cabins and club houses were being established also. Such areas were either being leased to sportsmen's organizations or being retained by the owner for private use; in some instances the work was being done as a cooperative project by the operator and the club. These areas were used by the club members and owners and also for the benefit of various youth groups such as the Future Farmers of America, Boy Scouts of America and those from orphanages. In some instances, fishing contests were sponsored for the youth groups.

WILDLIFE POPULATIONS

During the fall, winter and spring of 1946-1947, a 1,200-acre tract of land was studied intensively to determine the wildlife populations inhabiting each type of land unit. The study area was divided into four units with acreages as follows: reclaimed coal stripland 160, cropland 160, abandoned farmland 103 and forest-land 126. The remaining 651 acres were located between and adjacent to the four units and acted as buffer zones. Wildlife observed on these latter areas were not included in the census data.

The coal stripland unit had been developed largely during the period 1918-1923. The banks were ungraded and had been planted to black locust (*Robinia Pseudo-Acacia*) 1923-1926; red oak (*Quercus rubra*) 1926; red pine (*Pinus resinosa*) 1926, 1932, 1934; Scotch pine (*Pinus sylvestris*) and Austrian pine (*Pinus nigra*) in 1936. The black locust ranged up to 22 feet in height, red oak 28 feet and the conifers to 31 feet. Volunteer species included wild black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), white ash (*Fraxinus americana*), large-toothed aspen (*Populus grandidentata*), hazel nut (*Corylus americana*), blackberry (*Rubus* spp.), smooth sumac (*Rhus glabra*), elderberry (*Sambucus canadensis*), wildgrape (*Vitis* spp.), poison ivy (*Rhus toxicodendron*) and American bittersweet (*Celastrus scandens*). Herbaceous vegetation included Canadian bluegrass (*Poa compessa*), red top (*Agrostis alba*), yellow sweet clover (*Meliotus officinalis*), white sweet clover (*Meliotus alba*), alsike clover (*Trifolium hybridum*) and a variety of others. The locust plantations, although in a decadent condition, had an extremely dense undergrowth consisting of vines, shrubs, and herbs. Patches of blackberry, hazelnut and elderberry were scattered over much of the area with grasses and legumes situated largely in the ravines where sweet clover ranged up to four feet in height. Numerous marshes and potholes were present, including two small lakes having approximately 8 acres of surface area. The vegetative types were interspersed very well and rather long "lanes" of shrubs and herbs were present over the entire unit.

The cropland unit consisted of an above-average farm for this region of Ohio; however, no modern conservation practices were employed. Clean farming was evident, such as the mowing and burning of fence-row and streambank vegetation, the clipping of all stubble and pasture fields and grazing of the woodlot. During the year of this study there were 14 acres in alfalfa, 28 in wheat, 23 in corn, 13 in oats, 43 in pasture, 13 in timothy hay, 21 in clover hay, 18 in woodlot and 3 acres in orchard and vegetable gardens. Two small streams were present on this unit. The unit provided abundant food but inadequate cover.

The abandoned farmland unit contained 103 acres and had not been farmed since 1918 except for one 13-acre field. Parts of the unit had been grazed for a few years. The vegetation was typical for such land in southeastern Ohio, with the dominant species being poverty grass (*Danthonia spicata*), goldenrod (*Solidago canadensis*), common cinquefoil (*Potentila canadensis*) and broom sedge (*Andropogon virginicus*). Patches of blackberry, elderberry, and dewberry (*Rubus villosus*) were quite common while wild black cherry, domestic apple (*Malus* spp.), crab apple (*Malus* spp.), and hawthorn (*Crataegus* spp.) were present in the fencerows. There were two decadent orchards and three small woodlots totaling 12 acres. Five springs and two small streams were present. In general there was fairly good cover, either located in patches or in the fencerows.

The forest unit consisted of 126 acres of second-growth trees. Timber cutting operations included the selective removal of some trees in 1915, 1918 and 1919, while a few small areas, one to two acres in size, were clear-cut for fence posts and mine props during the period 1930-1935. A timber cruise in 1947 indicated approximately 255,000 board feet of lumber in trees with a d.b.h. of 18 inches or over. Red oak, beech (*Fagus grandifolia*), white oak (*Quercus alba*), red maple (*Acer rubra*) and tulip poplar (*Liriodendron tulipifera*) were the dominant species. Conspicuous undergrowth, especially in the areas which had been clear-cut, included wild grape, smooth sumac, blackberry, American bittersweet and pokeweed (*Phytolacca decandra*). Approximately 90 acres had been grazed lightly over the years by both sheep and cattle. One small stream was present within the forest, while a fairly good-sized creek flowed along the south boundary. A total of 69 den trees were counted during the timber cruise.

TABLE 1. RESULTS OF DIRECT OBSERVATIONS

Land Units	C. Rabbit	B.-W. Quail	Individuals/1000 acres Woodchuck	Fox Squirrel	Pheasant	R. Grouse
Reclaimed coal stripland	125.0		6.3		6.3	
Abandoned farmland ..	107.0		19.4		9.7	
Cropland	25.0	87.5	43.8	6.3		
Forestland	8.0		7.9	3.9		15.9

RESULTS OF THE CENSUS

Although a considerable number of wildlife species were observed on the various units, a complete tabulation is not given here. Cottontail rabbits (*Sylvilagus floridanus mearnsi*), raccoon (*Procyon l. lotor*), woodchucks (*Marmota m. monax*) and the song and insectivorous birds were fairly abundant and thus relatively easy to census. The census data given for these species indicate a fairly reliable trend as to population abundance.

Population studies on each unit by direct observations were carried on during Aug. 1 to Nov. 15, 1946. In applying the method, all areas of possible cover were traversed by the author in order to flush the wildlife present. The census period included both the early morning hours and late afternoon. Live trapping was done during periods preceding hunting season and afterwards with equal periods of time spent on each of the units while the results of the hunting season were obtained by both checking hunters in the field and having those who could not be contacted in the field fill out questionnaires. The results of the methods were then compiled in various ways, such as individuals per 1000 acres of each specific type of land use, per man hour spent, per trap and per hunter. The data presented in Tables 1, 2 and 3 are based on the population per 1000 acres of each land-use type.

The results of the population study indicated that the reclaimed coal stripland unit supported rather favorable populations in comparison to the adjacent land in other types of use. Since vegetation on the stripland unit was still rather immature, one would normally expect to find largely upland game species. As a standard species common to all units, the cottontail rabbit population provided the best

TABLE 2. RESULTS OF LIVE TRAPPING

Land Units	C. Rabbit	Opossum	Individuals/1000 acres Raccoon	Woodchuck	Weasel
Reclaimed coal stripland......	425.0		62.5	181.3[1]	6.3
Abandoned farmland	379.0	19.4			
Cropland	75.0				
Forestland	50.0	66.7	166.7	83.3	

[1]Trapping for woodchucks was done only on the stripland and forestland units.

TABLE 3. RESULTS OF HUNTER CHECKS

Land Unit	Individuals Bagged/1000 Acres					Individuals Observed/1000 Acres						
	C. Rabbit	R. Fox	R. Grouse	Raccoon	G. Fox	C. Rabbit	R. Fox	G. Fox	R. Grouse	B.-W. Quail	Raccoon	Deer
Reclaimed coal stripland	319.0	31.3				550.0	50.0	6.3	25.0	81.2	6.3	6.3
Abandoned farmland	19.0					262.2	9.7					
Cropland	6.3	6.3[1]				12.5	6.3					
Forestland		13	13.0	129.9[2]	13.	6.5	13.0	39.0	26.0		155.8	

[1]Trapped in woodlot.
[2]An additional 9 raccoon, 8 muskrat and 2 mink were trapped along one mile of stream on the south boundary of the forestland unit.

trend. In each type of census applied the rabbit population was greatest on the coal stripland while the populations of other species such as the raccoon, woodchuck, ruffed grouse (*Bonasa u. umbellus*), and bobwhite quail (*Colinus v. virginiana*) were comparable to those populations present on adjacent land. During the entire study there was a total of 12 game species known to be inhabiting the coal stripland unit, at least on a seasonal basis, while there were 10 on the forest and 6 each on the abandoned farmland and on the cropland units.

Apparently superior habitat was a major factor in the greater populations present on the stripland as compared to the other land units. Black locust plantations with dense undergrowth, conifer plantings, "lanes" of shrubs, patches of grasses and legumes and excellent nesting sites on the spoil bank slopes all contributed to a good wildlife environment. During the periods of snow, the greatest concentration of rabbit tracks was observed in the dense undergrowth of the locust areas. In addition there was some patch farming carried on at the periphery of the stripland unit which was also a factor favoring the stripland habitat and possibly influencing population numbers. In contrast, the cropland had sufficient food but very little cover, except during the spring and early summer before the crops were harvested. It is significant that 40 per cent of the rabbits livetrapped on the 160 acres of cropland were trapped in a clump of rose bushes about 25 feet in diameter in the center of a pasture field. On the abandoned farmland there was adequate cover but food was probably a limiting factor while the forest lacked the food and cover essential for most of the species observed on the other units. Based upon track studies in the snow there was very little inter-unit movement of game. By recording the location and tagging each rabbit trapped, the movement of this species was observed. A total of 122 individual rabbits were trapped while 39 were trapped twice. Of 116 which were sexed, 70 were males and 46 were females. The range of movement of retrapped rabbits was generally not greater than 150 yards. One individual, however, was retrapped 1400 yards from where it had been tagged. The raccoon which was trapped on the coal stripland unit was believed to be foraging for food in the water areas and probably denning in adjacent woodlots. The grouse were inhabiting the locust and conifer plantations chiefly during the winter and spring months. It is quite possible they returned to the woodlots during the remainder of the year.

Ground dens of woodchucks were observed closely throughout the study for signs of their being used. In the fall of 1946, a total of 44 woodchuck dens were located on the cropland unit, of which all appeared to be in use, while during the winter 17 dens were observed, 5 of which were being used by rabbits and 2 by opossum. In May of 1947, 17 dens were checked, of which 15 were being used by woodchucks. A similar check on the abandoned farmland in the fall revealed 15 dens, all being used, while during the winter 7 were observed, 4 of which were being used by rabbits. In May, 43 dens were located and all showed signs of being in use. On the stripland unit 32 dens were observed and in use in the fall, while in the winter 65 dens were located, of which 55 were being used by rabbits, while 2 contained both rabbit and fox tracks. In the spring 216 dens were located, of which 195 appeared to be in use. It is believed that many of these dens were merely used as escape dens while woodchucks were moving about from one area to another.

SONGBIRD STUDY

During the population studies the non-game birds, such as the song and insectivorous and raptorial species, were also counted. In the spring of 1947 a bird count was conducted on three of the land units. The results of the census are given in Table 4. Probably the diversified cover types present on the stripland unit encouraged the presence of both a greater number of species and individuals than on the other land units. During the entire year of field observations, a total of 23 species were recorded for the stripland, 18 for the cropland, 17 for abandoned farmland and 16 for forestland.

WATER AREAS

Following the removal of the coal, the depressions between the spoil banks and in the final cuts usually fill with water to form lakes, ponds,

TABLE 4. THREE-HOUR NON-GAME BIRD CENSUS[1]

Land Unit	Total no. of species	Total no. of individuals	Population/ 1000 acres
Reclaimed coal stripland	13	41	256
Cropland	10	17	107
Abandoned Farmland	9	17	165

[1]Forestland not censused due to an abrupt change in weather conditions.

marshes, and potholes which vary in size from a fraction of an acre up to several acres in surface area. Usually in Ohio the lakes are not over 20 feet in depth, while the majority range from 10 to 12 feet.

The chemical conditions of the water, such as pH, dissolved O_2 and fertility, are largely dependent upon the character of materials in the geologic strata which forms the watershed and basin. The method of stripping and the disposal of coal wastes are also factors which influence the chemistry of the water. The pH of the water was found to range from 2.5 to 8.2. In Ohio variances in the pH were related to the type of overburden, in that lakes in Harrison County had watersheds containing considerable calcareous materials and generally had a pH of 7.5 to 8.2, while in Tuscarawas County where the overburden consisted of acid shales and sandstone, the pH ranged from 4.5 to 6.5. Extreme acid conditions in one Jackson County lake in 1952 produced a pH of 2.5. In any water area an extremely low pH may be present if "gob" or waste coal happens to be placed where water flows over it. Marcarite (FeS_2) present as thin layers in the coal or as crystals in the immediate overburden is the major factor in determining how acid the water will be. Natural buffering by the other materials, such as limestone or fossiliferous shale may aid in reducing the effect of the marcasite.

The vegetation in and around the water areas generally consisted of narrow-leaf cattail (*Typha angustifolia*), arrowhead (*Saggitaria latifolia*), waterlily (*Nymphea tuberosa*), needle spike rush (*Eleocharis acicularis*), moss (*Drepanocladus fluitans*), burreed (*Sparganium* spp.), common waterweed (*Elodea canadensis*), pondweed (*Potamageton crispus*), watershield (*Brasena Schreberi*) and coontail (*Ceratophyllum* spp.). In some lakes only small amounts of aquatic vegetation were present in zones around the edge, but in two the waterlily and coontail were quite abundant.

The water areas were used extensively by various species of animal life. On the reclaimed coal stripland unit two lakes were present, totaling approximately eight acres. During the spring and fall migratory season, a total of 11 species of waterfowl and 4 species of shorebirds were observed resting and feeding on or around the two lakes.

On two occasions in Sept. and Oct. of 1949, the author observed a total of 43 mallards (*Anas p. platyrhynchos*) and 100 wood ducks (*Aix sponsa*) on the 7-acre lake. Studies during the period of 1948-1952 revealed a total of 15 species of waterfowl utilizing Ohio stripmine lakes while two species, the wood duck and mallard, were found to be nesting on such areas.

Furbearers in these two lakes and in adjacent marshes included only the muskrat (*Ondatra z. zibethica*), while in recent years the beaver (*Castor c. canadensis*) has been observed in several stripmine lakes. The former was found to be overwintering in water areas with a pH as low as 4.0. In addition to these species, raccoon and mink were known to forage for food in the vicinity of the water areas. The aquatic habitats of coal striplands are fairly productive of furbearers. Two lake owners in Ohio reported an annual harvest of three and eight muskrat pelts per acre of water. One land owner in Illinois indicated an annual income of \$500 to \$800 from trapping furbearers on the water areas of 600 acres of striplands.

A total of 15 species of fish were found in Ohio in stripmine lakes. Stockings of bluegills (*Lepomis m. macrochirus*) and largemouth black bass (*Huro salmoides*) have been successful and growth has been good. Recently brown trout (*Salmo trutta*) have been stocked in one stripmine lake and have survived, but no reproduction has been observed. Some species removed from stripmine lakes included largemouth black bass, 27 inches; bluegills, 9 inches; brown bullheads (*Ameirus n. nebulosus*), 11 inches; smallmouth black bass (*Micropterus d. dolomieu*), 20 inches; and common suckers (*Catostomus c. commersonnii*), 16 inches.

PLANT SPECIES USED IN WILDLIFE MANAGEMENT

The forestry plantations and pasture seedings studied were located on the various spoil types and ranged in age from one to 34 years in Ohio while one naturally revegetated area in Illinois was well over 50 years in age. Several species of plants were present and were of considerable value for use in managing strip-mined land for wildlife.

The majority of the hardwood plantations generally were still relatively immature and their value in producing wildlife habitat could not be evaluated completely. Of the group, black locust was the outstanding hardwood and produced a closed canopy after three growing seasons when spaced six feet apart while by 10 to 15 years a dense undergrowth was present. This species has always been widely used in Ohio for coal stripland reclamation because of its apparent adaptability to extreme site conditions and its rapid growth. Others such as wild black cherry produced tremendous amounts of fruit while red oaks (1926) were producing some mast.

Conifers were also of value in producing cover both on the banks and in adjacent old-field areas. Generally the canopy was not closed until 15 years, at which time a fairly good undergrowth had developed, especially where there had been some mortality. The conifers, however, provided much needed winter cover on the striplands of Ohio. Wildlife, including the ruffed grouse, bobwhite quail, cottontail rabbit, woodchuck, white-tailed deer (*Odocoileus v. virginianus*) and the mourning dove (*Zenaidura macroura*), utilized conifer plantings quite extensively. Twelve mourning dove nests were observed in a six-acre conifer planting 15 years old.

Shrub species including multiflora rose (*Rosa multiflora*), false indigo (*Amorpha fruiticosa*), Scotch broom (*Cytisus scoparius*), smooth sumac, coral berry (*Symphoricarpos vulgaris*) and bicolor lespedeza (*Lespedeza bicolor*) all were in use and doing very well where site conditions were satisfactory. Three outstanding species including rose, scotchbroome and bicolor were doing very well on acid (pH 4.5 to 5.5) spoil material. Bicolor seedings made in 1947 were ranging up to 96 inches in height, while Scotch broom after four growing seasons had a basal foliage diameter of 65 inches. The latter species remained green throughout the winter. Native species found to be doing well were American bittersweet, greenbrier (*Smilax glauca*), dewberry, wildgrape, poison ivy, blackberry, elderberry, hazel nut and winged sumac (*Rhus copallina*).

Other legumes and grasses included serecia lespedeza (*Lespedeza serecia*), Korean lespedeza (*Lespedeza stipulacea*), yellow and white sweet-clover, alsike clover, alfalfa (*Medicago sativa*), *rye grass* (*Lolium perenne*), smooth broome grass (*Bromus inermus*), and Kentucky blue grass (*Poa pratensis*). They were used either as pure or mixed seedings. Depending upon the site, some were providing better habitat than others. Serecia was doing very well on medium acid spoil as far north as Youngstown, Ohio, while Korean was doing well as far north as Zanesville, Ohio. All were growing on untreated spoil but were generally making better growth on calcareous spoil than on acid spoil. The plant growth on either acid or alkaline spoil was sufficient, however, to be of considerable value to wildlife.

At present the majority of the stripmine companies who are members of the Ohio Reclamation Association,[2] are planting most of the species mentioned in this paper. Where native species cannot be ob-

[2]The Ohio Reclamation Association, under the directorship of Larry Cook, consists of 113 member companies and employs three foresters, one agronomist and one wildlife technician to plan their reclamation program.

tained from nurseries, they are being collected in the field by members of the reclamation staff. During 1953, the Association and its member companies planted a total of 2,295,157 trees and shrubs, including 801,439 black locust, 172,486 red, white and chestnut oak, 6,735 black walnut, 105,950 pine, 14,775 multiflora rose, 10,600 bicolor lespedeza, 6,078 mulberry, 2,157 dogwood, 6,963 cherry, 2,373 redbud, 800 hickory and 650 honeysckle and Scotch broom. Plants used specifically for wildlife food and cover are placed in the haulroads, in the firelanes, at the edge of forest plantings or as a small patch within the forest or pasture unit. Multiflora rose is widely used as a living fence around the edge of the major reclamation unit.

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation for the helpful guidance and assistance given by Dr. Charles A. Dambach, chief of the Ohio Division of Wildlife, the Ohio Department of Natural Resources, who was the author's advisor during the entire study; Dr. Daniel L. Leedy, U. S. Fish and Wildlife Service, who aided the author during the early phase of the study; the Ohio Cooperative Wildlife Research Unit for financial assistance through a Wildlife Research Fellowship;[3] the Ohio Reclamation Association who provided financial assistance through a Fellowship established in the Ohio State University Graduate School; and to the many land owners who graciously gave information and assistance in regards to stripmine reclamation.

SUMMARY

1. The development of coal stripmining began in Ohio on a large scale with the beginning of World War I and by the end of 1952, an estimated 77,625 acres had been affected. The coal striplands were located in 28 counties largely in unglaciated southeastern Ohio. Reclamation measures had been applied to an estimated 52,303 acres. Approximately 50 per cent of the affected land was located in the Harrison, Jefferson, Belmont County area.
2. The stripland topography is either one of a series of ridges and ravines (5 to 55 degrees) or one which has been graded to a gently rolling or undulating terrain.
3. Reclamation of the coal striplands in Ohio generally follows a multiple-use plan, including forestry, grazing, wildlife and horticulture. Spoil capability, which is a major factor in determining the type of vegetation to be used in reclamation, depends to a

[3]The Ohio Cooperative Wildlife Research Unit is cooperatively maintained by the Wildlife Management Institute, the Ohio Division of Wildlife, the Ohio State University and the U. S. Fish and Wildlife Service.

large extent upon the geological formation affected. Extremes in pH range from 3.5 to 8.0, with the usual range being 4.5 to 6.5. Trees are used on the more acid spoils while grasses and legumes are used on the calcareous or slightly acid spoils. Wildlife plantings are made either with the forest plantation or pasture seeding, while in some instances the complete stripland unit is developed as a wildlife and recreational area.

4. An intensive study was made of reclaimed coal stripmined lands, largely in Ohio, (1) to determine the wildlife inhabiting such areas in comparison to those present on adjacent cropland, abandoned farmland and forestland, (2) to determine the value of stripmine lakes for fish and other animal life and (3) to evaluate current reclamation practices and plant species used in producing wildlife habitat.
5. A total of 82 forest plantations and pasture seedings and naturally established coverts were studied to determine their value in producing wildlife habitat. Twenty-four water areas were studied to determine the chemical conditions and the plant and animal life present while a census was conducted on a 1200-acre tract of land to determine the relative wildlife populations and species utilizing the various land use units.
6. Direct observations revealed a total cottontail rabbit population per 1000 acres of: 125 on the reclaimed coal stripland, 107 on the abandoned farmland, 25 on the cropland and 8 on the forestland. Live trapping for the same species revealed 425 per 1000 acres of reclaimed stripland, 379 on abandoned farmland, 75 on cropland and 50 on forestland. Hunter checks indicated 319 rabbits shot per 1000 acres of stripland, 19 for abandoned farmland, 63 for cropland and none for the forest unit.
7. Livetrapping resulted in 62.5 and 166.7 raccoon and 181.3 and 83.3 woodchucks per 1000 acres of stripland and forestland respectively.
8. Data resulting from the research revealed 12 game species inhabiting the reclaimed coal stripland, 10 on the forest and 6 each on the cropland and abandoned farmland.
9. There was a total of 216 woodchuck dens observed on 160 acres of the reclaimed coal stripland. Of the total, 195 revealed signs of being used during the spring. The dens were being used considerably by cottontail rabbits during the winter season.
10. There was a total of 23 species of song birds observed on the reclaimed stripland, 18 on the cropland, 17 on the abandoned farmland and 16 on the forestland. A spring census on three of the

land units revealed populations of 256 individuals per 1000 acres of reclaimed stripland, 165 on the abandoned farmland and 107 on the cropland.

11. A total of 15 species of waterfowl were observed resting and feeding on stripmine lakes during the migratory seasons while wood ducks and mallards were found nesting around such lakes in Ohio.
12. Furbearers, including the muskrat and beaver, were present in Ohio stripmine lakes with two lakes producing a muskrat harvest of three and eight pelts per acre. Raccoon and mink also foraged for food around the water areas.
13. A total of 15 species of fish were found in Ohio stripmine lakes with growth equal to those fish present in non-stripmine areas. Brown trout have been stocked successfully in one stripmine lake but there was no evidence of reproduction.
14. Various plant species of value in producing wildlife habitat on coal striplands were black locust and some of the conifers. The locust provided a closed canopy and a dense undergrowth earlier than any other hardwood species, although red oak planted in 1926 were producing mast in 1949. Conifers provided cover later than the locust but the foliage being present throughout the year increased their value to wildlife.
15. Shrub species including false indigo, smooth sumac, bicolor lespedeza, Scotch broom and mulitiflora rose were all of considerable value to wildlife. The latter three were doing well on medium acid spoils with bicolor reaching 96 inches in height. Some native shrubs were also doing well on the coal striplands.
16. Other plant species including serecia lespedeza, Korean lespedeza, sweet clover, alsike clover, alfalfa, rye grass, smooth broom grass and Kentucky blue grass also were doing very well depending upon the specific site. Serecia and the sweetclovers provided both cover and food and were doing well on relatively poor sites.
17. With the ever increasing demands made upon the land by the human population increases in Ohio, properly reclaimed and managed coal striplands will help to alleviate the pressures from the increased numbers of sportsmen and recreational seekers. Coal stripmining may eventually affect 250,000 acres in Ohio.

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DISCUSSION

MR. ROBERT RECK (Ohio Department of Natural Resources, Columbus, Ohio): To what extent does the state subsidize this reclamation program?

DR. RILEY: Don't use the word subsidize. The state doesn't put one cent into any strip-mined land. All of it is privately owned and every strip-mining operator is required to pay a $50 license fee plus, I think, $190 per acre for each of land he plans to disturb during the year and he can't pay less than $1,000. That money is put with a bonding company and is held there until the state officials say he has done an adequate job of reclamation on it. So, the state is not putting one cent into it.

MR. RECK: Is that due to the fact these owners are turning back land higher in value to the public than the land they stripped in the first place?

It seems to me from your figures there that the land, after it was reclaimed by the strip miners, was more valuable than what it was to begin with, and since it is available to the public for hunting in a great many cases, is it quite fair that the state doesn't subsidize this reclamation program?

DR. RILEY: I imagine you had better be careful where you ask that question in Ohio. The land in many instances is producing more now than it was before, but I don't think you will ever come to the point where the state will put any money into the reclaimed lands unless they can use them as public hunting reserves or something like that. There are some areas in the extreme southern part of the state which are probably not as prductive as they were before, but in many other areas, expecially in the Jefferson-Harrison region, where 50 per cent of the strip-mined lands are located, they probably are producing more than before. However, that land before it was bought up, may have produced more than it does now. The former owners just didn't have the money to put the material into it.

MR. RECK: It has been my impression that the state has been rather negligent in their obligations to the general public. In Pennsylvania it is a general practice to forget the money, rather than to go to the trouble of reclaiming the land, and there again, the state seems to be negligent, bcause they never seem to get around to reclaiming it, although they have the forfeited bond money in their possession. And it seems to me we should direct a little more of our attention to the states rather than to the operators themselves.

DR. RILEY: We have the same problem in a few instances in Ohio, where a fiy-by-nighter comes in and doesn't have adequate equipment and tears the land up, takes the coal out and forgets the bond. However, the state people have been making plans to see that the money is held for the specific unit of land and the state will pay it out to a reclamation company and they will reclaim the land. In other words, it won't be similar to what has taken place in Pennsylvania.

ANIMAL POPULATION FLUCTUATIONS IN ALASKA—A HISTORY[1]

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This paper is a history of the more pronounced fluctuations of selected animal species in Alaska; it is entirely descriptive, and does not discuss causality. In the paper I have attempted to draw together the pertinent information from all possible sources, principally the records maintained by the Alaska Game Commission and the U. S. Fish and Wildlife Service since 1925, replies to questionnaires sent out from the University of Alaska in 1951, data from personal interviews, and information gleaned from published accounts. Although nearly a thousand publications were examined, only those cited contained statements of abundance. It is hoped that the material presented will provide additional grist for vigorous analysts to examine.

The data from 1925 to date for small game, and from 1912 to 1953 for fur animals, are by far the best, though even these leave much to be desired. Records from 1900 to 1924 are subjective estimates, but are relatively abundant and present a rather clear picture of the fluctuations. Prior to 1900, records are sparse, and observations for several consecutive years in the same locality are nearly nonexistent. The principal exception is the record of the Russian American Company fur purchases, but this is sufficiently detailed for our purposes only for the years 1842 to 1860.

SMALL GAME

The information presented in this section concerns almost entirely that portion of Alaska lying west of 138° west longitude. The hunter harvest data of Figure 1 and Table 1 embody the entire Territory, but the kill of grouse, ptarmigan, and snowshoe hare in Southeastern Alaska seldom exceeds 10 per cent of the total harvest, and probably does not influence our kill data significantly. Southeastern Alaska is omitted from discussion here because grouse and ptarmigan populations apparently remain relatively stable, and snowshoe hare populations are never large and occur only in the major river valleys.

There are, in that portion of Alaska with which we are concerned, three species of ptarmigan, three of grouse, and two of hare. Since reports do not always distinguish between the various species, the

[1]Contribution from the Alaska Cooperative Wildlife Research Unit; Alaska Game Commission, University of Alaska, U S. Fish and Wildlife Service, and the Wildlife Management Institute, cooperating.

hares, grouse, and ptarmigan will be treated as groups rather than as species.

Hares. To avoid confusion, the word "rabbit" will be used to refer to the snowshoe hare (*Lepus americanus*), and the word "hare" will refer to the arctic hare (*Lepus othus*).

Nelson (1887), writing of the period 1877 to 1881, gives us our earliest record of rabbit populations. He says "Some years ago they became excessively abundant along the Upper Yukon, but an epidemic broke out among them one winter and nearly exterminated them throughout several hundred square miles of country and many died elsewhere." Our next record for the Interior is that of Allen (1887), who traversed the valleys of the Copper, Tanana, Koyukuk, and Yukon Rivers in 1885. Rabbits were one of the major sources of food of the party and were considered to be abundant.

Unfortunately, we have no further record until 1898. As this time Spurr (1900) found rabbits scarce along the Upper Kuskokwin River. He heard that rabbits were common in the Susitna Valley, but saw only one—a possible indication of recent decline. In 1899, Osgood and Bishop (1900) reported that rabbits were scarce, and that it was an "off" year along the entire Yukon River. Schrader (1900), who traveled along the Upper Koyukuk River in the same year, made no mention of rabbits in his list of animals, thus indicating scarcity. Osgood (1901) indicates that rabbits were common around Cook Inlet in 1900. In 1902, he considered them to be common near Lake Clark and along the Chulitna River (Osgood, 1904). In 1903, they were "fairly common" between Eagle and Circle where not one had been seem in 1899, and they were common in the low country of the Ogilvie Mountains in 1904 (Osgood, 1909). In 1905, Georgeson (1905) stated that "Rabbits are so numerous about Rampart as to be a veritable pest." He mentions that gardens and grain fields had to be fenced to prevent total destruction of the crops by rabbits near Rampart and that the tree nursery at Copper Center was attacked by rabbits, which caused considerable damage. Sheldon (1930) observed that rabbits were scarce in 1906 and scarcer in 1907 in the area that is now Mount McKinley National Park. According to Nelson (1909), rabbits were abundant in the Copper River Valley in 1906 and died off in 1907; and in 1908 they were scarce in the Innoko and Tanana River Valleys. Smith and Eakin (1911) saw no rabbits on the Seward Peninsula or in the Nulato Hills in 1909.

By 1912, rabbits were increasing greatly in numbers. Moffit and Mertie (1923) reported them "exceedingly plentiful" from 1912 to 1914 in the Wrangell Mountains, and Eakin (1914) stated that they were "plentiful" in the Iditarod-Ruby district in 1913. Georgeson (1914), referring to 1913, said, "Around Fairbanks rabbits did much damage. They have increased so rapidly of late years that they have became a serious pest. . . . There was literally thousands of them." Murie (1920) indicates that rabbits were plentiful along the Chena River in 1915, that in 1916 they were fewer, and that in 1917 they were scarce. Hasselborg (1918), remarking on the abundance of horned owls on Admiralty Island in March, 1918, attributed the abundance of owls to an emigration following the die-off of rabbits in 1916 in the Interior. Respondents to the Alaska Game Abundance questionnaire, sent out by the University of Alaska in 1951, indicated high rabbit abundance on the Lower Kuskokwim and Yukon Rivers from 1913 through 1916, on the Kenai Peninsula in 1913 through 1915, in the Susitna Valley in 1913 and 1914, near Fairbanks in 1913 through 1915, and in the Copper River Valley in 1916. Large numbers of dead rabbits were reported by some of the same respondents in the fall of 1913 on the western side of the Kenai; in interior Alaska, on the Seward Peninsula, and on the entire Kenai Peninsula in 1916; and in the Copper River Valley in 1917. Numbers were reported to be at a low ebb throughout the Territory from 1917 through 1920.

All information points to a rapid increase in all of Alaska from 1920 through 1924. At Fairbanks "In 1924, the rabbits were so numerous that they destroyed crops at the station and caused heavy losses on neighboring farms and in local gardens. In 1925 the numbers of rabbits appeared equal to that in the preceding year, and they destroyed cereal grains in the shock. In 1926 and 1927 the numbers decreased, and in 1928 and 1929 it was practically negligible and no crops were damaged" (Alaska Agricultural Experiment Station, 1930). Dixon (1938) records a peak in 1925 and decline during the summer of 1926 at Mount McKinley National Park; and Palmer (1938a), a peak in 1924-25 on the Kenai Peninsula.

From 1925 through 1952 (except for the years 1939-40, 1940-41, and 1943-44), the records of hunter kills maintained by the Alaska Game Commission and later the U. S. Fish and Wildlife Service provide us with a quantitative measure of hare abundance. Although the records lump the snowshoe rabbit and the arctic hare together under the term "hare," the bulk of the harvest is snowshoe rabbits. For the sake of year-to-year comparisons, the data are presented as "animals per hunter" in Figure 1. The actual harvest records and the number of hunters reporting are listed in Table 1. From these data it appears that rabbit populations were at a peak in 1926, again in 1935, in 1942 or 1943, and in 1947. Minima occurred in 1928, in 1938, 1939 or 1940, in 1943 or 1945, and in 1948 and 1950.

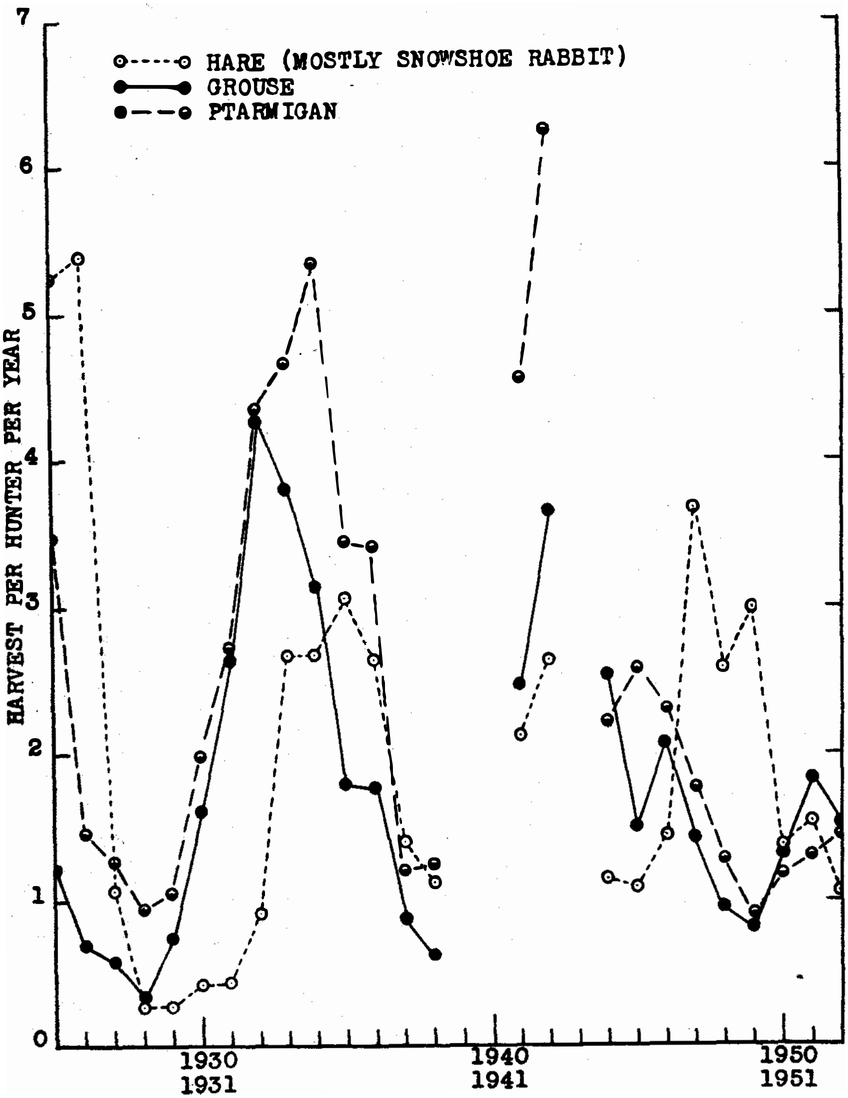

FIGURE 1. HUNTER SUCCESS ON GROUSE, PTARMIGAN AND HARE (MOSTLY SNOWSHOE RABBIT) IN ALASKA, 1925-26 TO 1952-53. BASED ON UNPUBLISHED RECORDS OF THE ALASKA GAME COMMISSION AND THE U. S. FISH AND WILDLIFE SERVICE.

TABLE 1. KILL OF SMALL GAME IN ALASKA, AND NUMBER OF HUNTERS REPORTING.[1]

Year	Grouse	Ptarmigan	Hare[2]	Number Reporting
1925-26	1,527	4,242	6,593	1,251
1926-27	1,649	3,364	12,571	2,325
1927-28	1,982	4,303	3,670	3,409
1928-29	1,242	3,426	831	3,628
1929-30	2,605	3,615	882	3,462
1930-31	5,272	6,385	1,286	3,242
1931-32	9,330	9,515	1,445	3,503
1932-33	12,533	12,659	2,634	2,931
1933-34	10,463	12,791	7,357	2,754
1934-35	7,650	13,015	6,494	2,441
1935-36	6,322	12,048	10,739	3,504
1936-37	9,343	17,824	13,841	5,238
1937-38	5,498	7,595	8,909	6,361
1938-39	3,770	7,623	6,887	6,124
1939-40				
1940-41				
1941-42	27,847	52,262	24,515	11,546
1942-43	38,354	65,750	27,775	10,490
1943-44				
1944-45[3]	34,495	30,237	15,567	13,689
1945-46	21,646	37,207	15,942	14,429
1946-47	33,065	36,512	22,924	15,870
1947-48	27,109	33,354	69,416	18,844
1948-49	20,301	27,432	55,057	21,214
1949-50	18,788	20,767	68,286	22,784
1950-51	33,523	28,951	33,932	24,845
1951-52	50,619	35,891	42,421	27,699
1952-53	49,400	48,000	35,000	32,915

[1]Based on records of the Alaska Game Commission and the U. S. Fish and Wildlife Service.
[2]Hare includes both arctic and snowshoe, but snowshoe make up practically all of the records.
[3]From 1944-45 to 1952-53 the figures are the estimated total take, extrapolated from the number actually reported.

Wardens' reports (Alaska Game Commission, 1926-1939) provide some insight into local irregularities of the rabbit fluctuations. Their reports indicate that a peak population occurred in 1925 over most of the Territory, but that a few areas in the Upper Yukon, Tanana, and Copper River Valleys retained high numbers through 1927. In the next decade, the peak was again reached in the western part of the Territory earlier (1935) than in the central portion (1936) and the eastern portion (1937).

During the 1940's the picture is somewhat obscure, indicating possibly that the peak was of a lesser magnitude than during the preceding decades, or that the degree of synchronization between areas was less than in previous peaks. Apparently the peak population in the Copper River Valley and on the Seward Peninsula occurred in 1945, and near Circle in 1946. Other areas have, for the most part, reported a gradual increase or stable populations since the early 1940's. In 1953, there were small die-offs in a few areas, but the overall picture was one of increase or continued high abundance. Detailed figures on distribution of the hare harvest, compiled by the U. S. Fish and Wildlife Service under Federal Aid Project Alaska 3-R, are available for the period 1947-48 through 1951-52. Most areas showed a decrease from 1947-48 to 1948-49, a slight increase the following year, a decrease from 1949-50 to 1950-51, and an increase in 1951-52. However, the Alaska Peninsula and Kodiak Island have shown a consistent decrease in harvest since 1947-48.

The arctic hare data are far less complete than those for the snowshoe rabbit. Nelson (1887) says that hare were abundant on the Yukon Delta in 1877, and Osgood and Bishop (1900) imply that hares were scarce in the Yukon Delta in 1899. These are our only records from the nineteenth century.

Moffit (1905) found few hares on the Seward Peninsula in 1903. Osgood (1904) states that arctic hares were scarce at the base of the Alaska Peninsula in 1902 and that there were more in 1903. In 1908 there were some hares in the same area, but they were not abundant (Atwood, 1911). Obviously, our data are insufficient to delimit periods of abundance and scarcity.

Our best information stems from the reports of hares shipped from Alaska. These records are listed in Table 2 for the period 1912 to 1953. The peak years have been near the middle of each decade. It is of interest to note that in each period of large shipments there are two peaks, separated by a year with low shipments. One possible explanation is that two rather distinct populations are involved: perhaps one on the Alaska Peninsula, and one on the rest of the mainland. Evidence for this hypothesis is available from observer's reports during the 1930's. During this decade, hare populations reached a peak on the Alaska Peninsula in 1935 followed by a decline in 1936; on the Seward Peninsula and on the Yukon-Kuskokwim Delta populations remained high in 1936 and 1937. Unfortunately, we have no such data for the other decades.

Grouse. Our data for grouse are very similar to those for the snowshoe hare. Our first glimpse of the grouse of Alaska is provided by Turner (1886), who found ruffed grouse (*Bonasa umbellus*) and spruce grouse (*Canachites canadensis*) abundant at Nulato in 1875. McLenegan (1889) found spruce and ruffed grouse to be "sparingly present" on the Kowak (Kobuk) River in the summer of 1884. Townsend (1887), traveling in the same area the following year, saw spruce grouse only once and does not include the ruffed grouse in his list of birds of the area. It seems likely that there was a decrease in numbers between the two years, but whether 1884 or an earlier year was the peak is not clear. Allen (1887) does not mention having seen any grouse in his travels, which leads me to believe that they were scarce throughout the interior in 1885.

Our next clue to former conditions comes in the following decade. Mendenhall (1900) states that blue (here = spruce) grouse were abundant in 1898 between Resurrection Bay and the Tanana River. Spurr (1900) found grouse quite abundant along the Upper Kuskokwim River in 1898, and Grinnell (1900b) noted that spruce grouse were common in the Kowak (Kobuk) River Valley in 1898 and 1899. In 1899, grouse were abundant at Chitina and in the Skolai Mountains (Rolin, 1900) and along the Chandalar and Koyukuk Rivers (Schrader, 1900). We have no reports for 1900, but in 1901 Mendenhall (1902) saw a few spruce grouse between Fort Hamlin and Kotzebue. In 1902, Osgood (1904) found more spruce grouse at the base of the Alaska Peninsula than he had previously seen in Alaska. In 1903, spruce grouse were rare between Eagle and Circle on the Yukon River, while sharp-tailed grouse (*Pedioecetes phasianellus*) were not uncommon, and ruffed grouse were present in small numbers; spruce grouse were rare in the Ogilvie Mountains in 1904 (Osgood, 1909).

During the next several years grouse were not abundant. Sheldon (1909) considered spruce grouse common in the timbered areas along the Upper Toklat River in 1907 and 1908; in 1908, Maddren (1910) says that grouse were sometimes seen on the Innoko River; and Moffit and Knopf (1910) saw an occasional grouse in the Nabesna-White River Region. In 1909, grouse were abundant in many parts of the Koyukuk-Chandalar Region (Maddren, 1913). Smith (1913) found spruce grouse common enough to be depended upon for food in the Kobuk Valley in 1910. In his report on a trip through the Tanana and Kuskokwim Valleys in 1911 and 1912, Dice (1920) found that spruce grouse and ruffed grouse were common, and that sharp-tailed grouse were numerous near McGrath. He reports that the latter species had been found that far west only in recent years. In 1912, spruce grouse were abundant in the Prince William Sound area (Capps and Johnson, 1915), and in 1913 grouse were plentiful in the Iditarod-Ruby (Eakin, 1914) and Koyukuk Regions (Eakin, 1916).

Questionnaire respondents indicate ruffed grouse abundance in 1912 and 1913 at Fairbanks, in 1914 and 1915 on the White River, in 1915 at the headwaters of the Holitna and Nushagak Rivers, and as late as 1917 and 1918 at McGrath. Sharp-tailed grouse and spruce grouse were reported to be abundant in the Nabesna Region in 1913. At Big Delta, sharptails were notably scarce from 1916 through 1918, though they had been abundant previously.

Bailey (1919) reports that grouse were very scarce in 1919 in the Copper River Valley. The same author (Bailey, 1921) states that they were increasing rapidly at Anchorage and Talkeetna in 1920. In 1921 a few grouse were seen on the west side of Cook Inlet (Moffit, 1927). Murie, reporting in 1922, indicated a great increase in sharp-tailed grouse and spruce grouse, and a good increase, but less than in the other species, in ruffed grouse at Fairbanks. Clarke (1936) states that the peak in ruffed and sharp-tailed grouse was in 1922-23, followed by a decline in 1924 and minimum numbers in 1927, but he does not specify the portion of Alaska to which he is referring.

Bailey (1948) reported spruce grouse plentiful in the Kobuk region in 1922. Apparently the peak was reached on the Kenai Peninsula in 1922, for Culver (1923) found spruce grouse scarce in 1923 but heard that they had been abundant the preceding year. The Governor's Report (Anonymous, 1923) indicated that grouse were abundant and increasing throughout the Third and Fourth Judicial Divisions in 1923. Brandt (1943) states that spruce grouse were common on the lower Yukon River in 1924, but that ruffed grouse were at the bottom of their cycle; and Capps (1927) found grouse abundant in the Matanuska Valley in the same year. Reports from 1926 to 1930 indicate scarcity throughout Alaska: in Mount McKinley National Park from 1926-1930 (Dixon, 1938); along the Sheenjek River in 1926 (Smith and others, 1929) and 1927 (Smith and others 1930a); Stony River in 1928 (Smith and others, 1930b); and the Lake Clark-Mulchatna area in 1929 (Smith and others, 1932).

The peak for grouse populations through most of Alaska, then, was 1924-25, but with some of the easternmost portion of the Territory retaining high abundance for a year or two later, and the Kenai Peninsula peak earlier.

The hunter success ratios for grouse are shown in Figure 1. Peaks in the populations, judging from these figures, occurred in 1932, in 1942 or 1943, and lesser peaks in 1946 and 1951. Observers' reports, however, offer conflicting evidence. Reports of the wardens (Alaska Game Commission, 1926 through 1939) indicate that spruce grouse, ruffed grouse and sharp-tailed grouse in the same location fluctuate at the same time. These reports also indicate that peak grouse populations were evident in Alaska in 1935, and that they were decreasing or were scarce by 1936. Cade and Buckley (1953) report that sharp-tailed grouse were abundant at Fairbanks in 1934, and scarce in 1935, whereas the wardens' reports indicate abundance of all species at Fairbanks in 1935. Perhaps the best explanation of the apparent discrepancy in peak period dates is that spruce grouse, which constitute the greatest part of the kill, may have decreased in some areas before the other species of grouse. This seems especially likely for the Kenai area, where spruce grouse did decline prior to ruffed grouse in the preceding decade.

Observers' reports corroborate the years of abundance deduced from the kill records for the 1940's, but, as with the hares, the peaks were not so high and the pattern not so clear as in earlier decades.

Ptarmigan. Our data on ptarmigan pre-date those for the other species, and are more complete. Adams (1878) observed in 1850-51 that willow ptarmigan (*Lagopus lagopus*) were seen in "small and scattered packs about the hills" near St. Michaels, and that this was the only grouse seen here. In the same region, Turner (1886) reported willow ptarmigan as numerous in 1877 (and, in fact, that they were numerous from 1874 to 1881 in this general region). Nelson (1883) found them abundant in 1879, and rock ptarmigan (*Lagopus mutus*) numerous, but less so than the willow ptramigan. At Barrow, willow ptarmigan were considered scarce by John Murdoch during 1881, 1882, and 1883 (Merriam, 1885), but Nelson (1883) saw large flocks of willow ptarmigan at Kotzebue Sound in September, 1881. In 1884, McLenegan (1889) found willow ptarmigan extremely abundant on the Kowak (Kobuk) River, and rock ptarmigan less abundant. In 1885, in the same region, Townsend (1887) stated that willow ptarmigan were not abundant, and did not include the rock ptarmigan in his list of birds.

Evidently the same decrease was widespread, for Allen (1887) does not mention ptarmigan in the report of his trip along the Copper, Tanana, Koyukuk, and Yukon Rivers in 1885.

We have a gap in reports from 1885 to 1898, at which time travels in Alaska became more extensive than formerly. Mendenhall (1900), Spurr (1900) and Grinnell (1900b), traveling in the Tanana Valley, the Susitna Valley, and the Kobuk Valley, respectively, all report ptarmigan common to numerous in 1898. In 1899, ptarmigan were abundant in the Copper River Valley (Rolin, 1900) and at Cape Nome (Grinnell, 1900a). By 1901, willow ptarmigan were considered very abundant and rock ptarmigan slightly less so in the areas between the Yukon and Kuskokwim Rivers by Mendenhall (1902), and the succeeding year on the Alaska Peninsula by Osgood (1904). In 1903, Moffit (1905) found ptarmigan abundant on the Seward Peninsula, and Osgood (1909) mentions that near Eagle willow ptarmigan were common and rock ptarmigan were abundant. In 1904, Osgood found willow ptarmigan "fairly common," in the Ogilvie Range and rock ptarmigan rare. The same year, Collier (1906) found ptarmigan common at Cape Lisburne. In the winter of 1904-05 both rock and willow ptarmigan were abundant on the Seward Peninsula (Anthony, 1906); and in 1906, 1907, and 1908 willow ptarmigan were abundant near Mount McKinley (Sheldon, 1909, 1930). The decrease on the Seward Peninsula must have occurred in 1906, since in 1907 Collier (1908) declared that they were scarce in the areas where they had been abundant in 1903, and Smith and Eakin (1911), writing in 1909, stated that ptarmigan were decreasing yearly. Leffingwell (1919) reports that ptramigan were scarce in the Canning River Region in 1907, and were more abundant in 1908. Reports for 1908 by Maddren (1910) for the Innoko Region and Moffit and Knopf (1910) for the Nabesna-White River country indicate scarcity, especially of willow ptarmigan. However, 1909 saw the beginning of another population upswing, with reports by Maddren (1913) that ptarmigan were abundant in many parts of the Koyukuk-Chandalar Region. Increases evidently continued during 1910 and 1911, inasmuch as Smith (1913) reported the birds abundant enough to be depended upon for food in the Kobuk Valley in 1910, and in the Alatna and lower Noatak Valleys in 1911; and Williams (1925) noted that ptarmigan were abundant in 1911 along the Alaska-Yukon Boundary near the Porcupine River.

The first signs of decrease were noted by Moffit and Mertie (1923), who observed that both rock and willow ptarmigan were very scarce in the Wrangell Mountains in 1914, as compared to 1912 and 1913. Elsewhere is Alaska in 1912, 1913, and 1914, there were continued increases as indicated by the reports of Leffingwell (1919) for the Canning River Region, Capps and Johnson (1915) for Prince William Sound, Moffit (1915) for the Broad Pass Region, Eakin (1916) for the Upper Koyukuk River, Dixon (1943) for the arctic coast between Barrow and Herschel Island, and Dice (1920) for the Yukon-Kuskokwim Delta and the vicinity of Nome. At Fort St. Michael, Hersey (1917) reported willow ptarmigan as very numerous in 1914, and scarce throughout the coastal region of Norton Sound in 1915. However, Hill (1922) reported willow ptarmigan common near Nome in the summer of 1915, and Blackwelder (1919) stated that they were common in the White Mountains during the same year. In 1916, ptarmigan were reported to be scarce in the Big Delta, Kenai Peninsula, White River, and Susitna Valley areas following abundance in 1915. Only Madsen (1916) on the Alaska Peninsula noted abundance in 1916.

The years 1917 through 1919 seem to have been a period of extreme scarcity throughout the Territory. In 1920, a rapid increase was noted at Anchorage by Bailey (1921), and in 1920 and 1921 in northwestern Alaska (Bailey, 1926). In 1921 and 1922 willow ptarmigan were common near St. Michaels (Bailey, 1948) and on the Seward Peninsula (Bailey, 1943), while Murie (1922) noted that willow ptarmigan were very numerous in 1922 on the flats around Fairbanks. For all of Alaska, the general picture was one of increase in 1923 and 1924, as cited by Culver (1923) for the Kenai Peninsula, Murie (1946) for Mount McKinley National Park, Capps (1927) for the Upper Matanuska Valley, and Conover (1926) and Brandt (1943) for the Yukon Delta. Abundance continued through 1925 on the Alatna, Unukserak, Kokolak, and Kilik Rivers (Smith and Mertie, 1925), and on the Alaska Peninsula (Smith and others, 1929). The year 1925 was evidently the peak in many areas, for in 1926 ptarmigan were scarce on the Skwentna River (Smith and others, 1929), and in 1926 and 1927 on the Sheenjek and the Chandalar Rivers (Smith and others, 1930a). At Mount McKinley National Park, numbers of willow ptarmigan continued high in 1926, and then decreased, reaching high numbers again in 1933 and remaining high until 1936 (Murie, 1946).

From 1925 onward I have the hunter-kill records of Figure 1 and Table 1 which are predominantly for the willow ptarmigan, but also include the rock ptarmigan and what few white-tailed ptarmigan (*Lagopus leucurus*) are taken. Evidently there was a peak in 1925, one in 1934, another in 1942 or possibly 1943, and a lesser peak in 1945. Minima occurred in 1928, 1937, and possibly 1939 or 1940, in 1943 or 1944, and in 1949.

Wardens' reports (Alaska Game Commission, 1926-1939) indicate increase throughout the Territory in 1931 through 1935. In 1936, however, reports from the Seward Peninsula, Yukon-Kuskokwim Delta, and the Alaska Peninsula indicated decreases. In 1937, the rest of the Territory also showed declines.

Observers' reports for the 1940's indicate abundance and decline first in the north and last in the south. The die-off in willow ptarmigan took place at Bettles in 1945 (Rausch, 1951), and peak abundance was evidently not reached south of the Alaska Range until 1946. As with the grouse and hares, the pattern is less clear during this decade than it was during the preceding ones.

Recapitulation. Snowshoe hares were increasing from an earlier fluctuation in 1881, and were abundant in the interior in 1885. We have no further information until 1898, at which time populations were at low levels but evidently increasing. By 1903, they were common, and had reached a peak of abundance in 1905 in the interior, except for the easternmost portion where they remained at a high level during 1906. By 1907, rabbits were scarce throughout Alaska; in 1912 large numbers were again present; and the peak was evidently reached in 1913 to 1915, with the die-off during 1916, except for the Copper River Valley and Lower Kuskokwim River, where populations remained high through 1916. The next peaks were in 1925 and 1935 in most of the Territory, with high numbers persisting in the Upper Yukon, Tanana, and Copper River Valleys until 1927 and 1937, respectively. During the 1940's there were several minor peaks, of which the highest occurred in 1946-47, but there was a notable lack of synchronization of peak populations between areas at this time. In 1953, populations were high and increasing throughout all of mainland Alaska. A few local die-offs may presage an impending decline.

Chitty (1948) summarizes the rabbit fluctuations in Canada since 1931 and permits us to fit the Alaskan data into the continental scheme. She says "Widespread mortality in 1934-35 was followed by recovery throughout Canada to general abundance which terminated first in Nova Scotia in 1941-42, last in the Yukon (1945-46). . . In Alaska a peak was reached in 1936-37; rabbits then became scarce and had not reached another peak by 1945-46." Apparently Alaska follows the same pattern, but lags a year or two behind northern Canada.

The arctic hare data are too few to indicate population changes prior to 1912. Based on reports of furs shipped from Alaska, hares reached peaks in 1914-1916, 1925-1927, possibly in 1938-1940, and in 1943-45. The peak in the 1930's is so low that its existence is questionable.

Spruce grouse and ruffed grouse were apparently at a population high in 1884 and declined in 1885. I have no data from the following decade, but in 1902 and 1903 a peak was reached, followed by decline in 1904. By 1908, grouse of all kinds were increasing throughout mainland Alaska, the peak apparently being reached in 1913 near Fairbanks, 1915 in eastern and southwestern Alaska, and not until 1918 in the Kuskokwim Valley. By 1919 grouse were notably scarce, but began to increase rapidly in 1920. The peak was reached in 1924 or 1925, but abundance continued in easternmost Alaska for a year or two longer. From 1926 to 1930, grouse were generally scarce, but sharp increases occurred in most areas in the early thirties. The peak was reached in most sections in 1935, but spruce grouse and sharptails had begun to decline earlier in some regions. There was a general increase from 1938 until 1942-43, followed by irregularly fluctuating populations for the rest of the decade. In 1953 there was an increase throughout most of the Territory, but a few areas in the Lower Yukon had begun to decline.

Willow ptarmigan were scarce in 1850-51 at Norton Sound; in 1877, they were abundant in the same area. In 1881, they were abundant at Kotzebue Sound, but were rare at Barrow from 1881 through 1883. In 1884 they were common in the Kobuk Valley, but in 1885 they were scarce in the same locality.

In 1898, ptarmigan, particularly willow ptarmigan, were common and apparently increased to a peak in 1905 to 1907. They were scarce throughout Alaska in 1908, but gradually increased to another peak in 1913 to 1915. Apparently the peak and subsequent decline took place in 1913-14 in the Wrangell Mountains, 1914-15 on the Yukon-Kuskokwim Delta, in 1915-16 in most of the Interior, and in 1916-17 on the Alaska Peninsula. The next peak occurred in 1925 in most of Alaska, but populations remained high until 1926 near Mount McKinley. During the next decade the peak was reached in 1935 in western Alaska, and 1936 in the central and eastern portions of the Territory. Reports of the 1940's are so conflicting that they lead to the assumption that the populations were lower and the fluctuations less pronounced. At the present time, ptarmigan of all species are abundant and increasing throughout the Territory.

FUR-BEARING ANIMALS

The data on furs shipped from Alaska have not previously been published in compiled form. For the sake of those interested in cycles, I have included this information for the period 1912 to 1953 in Table 2. The data have certain weaknesses, of which the chief ones are that furs are not always shipped in the calendar year in which they are caught, and that some furs, such as wolf, wolverine and lynx, are particularly valued for home use and hence are not shipped. Probably the bulk of the furs of the carnivores are shipped during the first three months of the year, and largely represent the harvest of the preceding fall. On the other hand, beaver, and muskrat pelts probably are shipped during the year in which they are taken. Current market quotations also alter the shipping schedule, and often the trapping intensity. And lastly, bounty payments of fifty dollars on wolves and thirty dollars on coyotes cause a higher trapping pressure on these species than would normally occur; on the other hand, many of the pelts of animals taken for bounty are not shipped, since some are taken when their fur is not prime and their pelt value very low. As an example, in 1953, 485 wolves and 347 coyotes were bountied and 100 wolves and 43 coyotes were taken by federal predator control agents, whereas only 100 wolves and 21 coyotes were shipped.

Marten and beaver are not even included in the table because trapping regulations for the past years have so altered their harvest that the records do not reflect the population levels.

The harvest of coyote also is of interest. Records disagree as to the exact year, but the coyote apparently first arrived in Alaska about 1915, and first entered the fur trade in 1925. A rapid increase and

TABLE 2. FURS SHIPPED FROM ALASKA, 1912 TO 1953.[1] BOLD FACE TYPE INDICATES PEAKS IN THE SENSE OF COLE (1954).

Year	Weasel	Mink[2]	White[3] Fox	Colored[4] Fox	Coyote	Wolf	Wolverine	Lynx	Hare	Muskrat
1912	7,957	31,363	3,610	8,766		103	189	2,720	55	123,925
1913	6,559	**47,062**	4,648	11,744		**163**	**242**	4,772	49	**163,616**
1914	6,873	35,623	**6,769**	**18,513**		44	136	6,930	**1,263**	101,202
1915	3,538	23,073	6,349	13,325		51	119	9,374	51	32,933
1916	4,345	22,255	**6,837**	**18,563**		57	297	**21,608**	**1,090**	**101,827**
1917	4,639	18,832	4,569	13,607		195	435	21,210	89	72,264
1918	9,133	24,572	**5,271**	**14,382**		207	**847**	7,692	38	86,624
1919	**18,617**	28,040	5,141	9,341		**284**	516	1,085	135	113.652
1920	13,590	**36,115**	4,943	7,829		87	**561**	649	**199**	138,443
1921	6,786	18,091	2,108	3,057		104	191	**3**18	197	218,737
1922	**10,656**	**31,983**	1,080	7,015		**183**	**296**	628	78	313,145
1923	10,276	20,668	**7,080**	12,039		166	**296**	1,385	96	**319,611**
1924	10,724	39,356	5,743	15,035		199	220	3,323	826	194,055
1925	**13,418**	**59,504**	**16,658**	22,314	61	**247**	360	**7,920**	**1,976**	**395,142**
1926	10,387	44,674	8,489	26,290	113	232	468	7,495	502	183,320
1927	8,663	**45,466**	2,849	26,686	191	468	809	9,809	**1,679**	155,041
1928	10,253	32,353	4,548	**30,686**	**621**	536	831	**10,173**	459	**197,957**
1929	**17,467**	26,695	**12,118**	25,201	480	**688**	**873**	7,575	401	190,377
1930	11,582	27,785	4,880	19,393	306	355	495	2,980	192	411,934
1931	15,358	30,431	5,643	13,953	206	263	406	623	79	455,897
1932	**17,536**	43,207	6,207	12,455	216	258	234	502	153	**500,640**
1933	11,372	50,812	**6,359**	14,763	299	387	**281**	591	**263**	154,573
1934	14,278	57,858	4,313	17,293	**439**	**757**	279	723	183	133,312
1935	**19,279**	**60,501**	**6,848**	19,531	297	642	260	1,338	**239**	127,901
1936	11,012	44,016	5,117	24,399	1,098	**904**	290	**2,421**	177	153,772
1937	8,453	**52,436**	4,912	**24,698**	1,330	730	**369**	2,089	110	231,842
1938	9,755	39,866	3,535	18,365	1,355	640	248	2,130	**335**	291,140
1939	**13,828**	42,883	4,198	**25,258**	1,507	405	228	**2,705**	89	417,442
1940	9,895	**43,702**	4,622	11,164	**2,080**	444	**326**	1,698	**270**	453,300
1941	8,550	31,782	**6,515**	**14,724**	1,208	**599**	232	781	60	**511,805**
1942	**11,280**	**53,060**	2,154	14,433	460	464	161	639	110	267,356
1943	3,892	33,705	**4,800**	6,418	376	351	92	713	195	212,352
1944	5,508	**61,038**	4,552	9,153	**797**	**418**	87	**990**	**700**	142,530
1945	5,967	31,339	3,652	**9,863**	474	290	108	922	337	152,542
1946	**6,629**	**64,837**	1,364	8,185	389	286	**157**	601	**578**	137,656
1947	4,815	42,772	**1,868**	7,774	**900**	**490**	**157**	**883**	132	**182,969**
1948	**11,121**	**55,429**	1,384	2,725	173	159	144	862	28	139.456
1949	6,482	23,268	398	1,749	90	144	125	560	**173**	146,230
1950	5,689	**27,468**	**2,613**	787	22	118	106	608	**173**	206,787
1951	**7,977**	21,697	654	**1,437**	56	78	**161**	**843**	0	**260,833**
1952	5,230	**39,198**	249	903	32	**113**	111	524	33	163,247
1953	2,979	25,061	2,009	349	21	100	118	730	99	138,074

[1]Data from Alaska Game Commission (1926-1939), and unpublished data in the files of the U. S. Fish and Wildlife Service, Juneau, Alaska.
[2]Mink season closed in portions of Alaska in Fiscal 1928,1929,1930, 1938, 1940, 1944, 1950 and 1954.
[3]Includes only white phase of arctic fox, to eliminate most ranch-raised fur.
[4]Includes red, cross, black and silver fox. The decline in fox pelts shipped from 1947 through 1953 is probably due to pelt prices, since the number of silver fox pelts has increased during the same period.

spread occurred, with the center of abundance first in the Tanana Valley about 1930, and now in south-central Alaska. At the present time coyotes occur as far west as the Alaska Peninsula and the north side of Bristol Bay, and have been found north of the Brooks Range.

The few records available from the ninetenth century are shown in Table 3.

The principal things that can be concluded from these data are that: lynx and colored fox, here as elsewhere, show peak populations a year or two after the peaks of hares and game birds; and that the other furbearers apparently fit Cole's (1954) "random fluctuations."

BEHAVIOR ASSOCIATED WITH POPULATION HIGHS

In addition to the subjective estimates, and the hunter-harvest data, there are several examples of erratic behavior that are probably correlated with high population densities. The most evident of these behavior patterns is emigration.

The first record of emigration by ptarmigan was provided by Dice (1920), who stated, "On September 16 [1912] several [willow ptarmigan] in a partially exhausted condition alighted on board our steamboat off the mouth of the Yukon near Kotlik, when we were about a half-mile from shore. After leaving Nome, September 26, with an offshore wind a flock of six or seven flew on board the ocean steamer when the nearest land was at least fifty miles away. These birds were completely exhausted and could easily be picked up in the hand. At that time of year many ptarmigan must perish in Bering Sea." The same phenomenon was observed by Conover (1926) at Hooper Bay, who reported that several times flocks of willow ptarmigan flew out to

TABLE 3. FURS PURCHASED IN ALASKA BY THE RUSSIAN AMERICAN COMPANY, 1842 TO 1860 (PETROFF, 1898). BOLD FACE TYPE INDICATES PEAK YEARS.

Year	Mink	White Fox	Wolf	Wolverine	Lynx
1842	741	2,545	11	46	150
1843	102	3,302	11	10	144
1844	98	3,021	9	67	35
1845	78	1,869	17	71	100
1946	160	3,866	8	111	162
1847	101	2,549	2	66	311
1848	148	2,176	4	22	323
1849	129	1,851	4	77	418
1850	99	1,786	7	131	497
1851	174	1,918	0	99	185
1852	6	2,736	5	80	49
1853	121	2,598	6	74	20
1854	39	2,112	1	46	14
1855	198	1,159	6	144	50
1856	107	2,335	0	39	112
1857	101	2,987	1	122	207
1858	42	2,610	4	73	356
1859	63	2,375	1	57	178
1860	59	1,943	0	68	73

sea in May, 1924. More recently, Captain Clyde Dell of the U. S. Fish and Wildlife Service vessel *Dennis Winn* observed a similar flight from the Trinity Islands near Kodiak. In September, 1951, "He observed large flights of ptarmigan heading out to sea from these islands, and possibly from Kodiak Island. On one or more occasions they landed on the *Dennis Winn* and considerable numbers of them landed in the water, apparently disregarding the fact that they were not equipped with proper water gear! On at least one such occasion, the wind was of such velocity that some of the birds were able to take off again and continue flight. Many others, of course, drowned. I have heard stories of such migrations to sea from the Seward Peninsula north of Nome, but this is the first verified description we have had." (Rhode, 1951).

A mass emigration of sharp-tailed grouse from the Tanana Valley in October, 1934, was reported by Cade and Buckley (1953). At this time enormous numbers of the birds left the area, and the species was scarce for the next several years.

Snowshoe hares have also behaved erratically. The most obvious evidence was the eating of creosote-treated telephone poles near Big Delta during 1951, 1952, and 1953. Residents of Fairbanks recall similar feeding near Cleary Summit in the middle of the 1930's. The rabbits also were eating coarse sand and fine gravel in recent years at Big Delta, and according to local observers, often do when they are abundant. It may be of some interest that three-fourths of the rabbits engaged in these types of feeding during 1952 were females; either pregnant, lactating, or both.

Still another evidence of increasing populations is the expansion of the population into unoccupied habitats near the periphery of the species range. This is occurring at present in the sharp-tailed grouse in the Copper River Valley, and was mentioned by Dice (1920) as having occurred in the same species in 1912 in the Kuskokwim area.

DISCUSSION

The data presented indicate that grouse and ptarmigan populations die off prior to, or concurrent with, the snowshoe hare. This is evident especially from the curves of Figure 1, and is of particular interest, since it tends to refute the suggestion of Lack (1954) that rodents decline first, thus forcing predator pressure on the game birds, and in turn bringing about their decline. There are few data from other areas where such a large variety of "cyclic" species occur together; it will be of interest to determine if the same pattern occurs in the future, now that we are prepared to study population changes in more detail.

It appears that the major pattern is for all species of small game to reach abundance and to decline in western and northern Alaska first, and for the population peak to advance easterly across the Territory, with a lapse of up to three years between the westernmost and easternmost portions of Alaska. Local irregularities often vary the pattern, or perhaps, local irregularities are what have caused the apparently cyclic pattern.

There is some evidence that the species of grouse, including the ptarmigan, do not "cycle" together, but the discrepancies have not exceeded a year or two at any one location. Detailed records and careful observation will help to clarify this pattern in the future.

SUMMARY

This paper, based on a review of published accounts and on replies to questionnaires, is a history of the more pronounced fluctuations of small game species in Alaska. Rock ptarmigan, willow ptarmigan, ruffed grouse, spruce grouse, sharp-tailed grouse, snowshoe hares, and arctic hares have tended to be most abundant near the middle of each decade since 1900. Evidence at hand suggests that the peak populations are not precisely synchronized as to area or species. Thus the hares have lagged a year or two behind the ptarmigan which in turn have lagged a year or two behind the other grouse in the same locations. Although a number of inconsistencies exist, it appears that peak populations and subsequent die-offs occur first in the north and west, with a lapse of up to two years before peaks occur in eastern and/or south-central Alaska. At the present time all small-game species are at high levels in most of the Territory; one or two areas have reported die-offs of one or more species this year. Several instances of emigration associated with high population levels are recorded.

The population levels of fur-bearing animals, based on reports of furs shipped, are also included.

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AN EVALUATION OF COTTONTAIL RABBIT MANAGEMENT IN PENNSYLVANIA

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INTRODUCTION

The cottontail rabbit (*Sylvilagus floridanus* and *S. transitionalis*) furnishes Pennsylvanians with more sport and recreation than any other game species. Increased hunting pressure and the aroused interest in beagling in recent years have created additional concern for effective methods for developing and maintaining adequate cottontail populations.

Cottontail management practices of various types have been carried on in Pennsylvania for many years. The first of these was restocking. The earliest attempt, in 1915, to increase cottontail numbers was by the transfer of a few hundred animals from the then lightly hunted northeastern and northwestern sections of the state to the areas surrounding Philadelphia and Pittsburgh. Importation of cottontails from midwesern and other states began in 1916 and continued until recent years. While the Pennsylvania Game Commission no longer imports cottontails for liberation (contrary to the desire of many sportsmen), many sportsmen's groups and individuals have continued this practice. During the 1930's artificial propagation in pens was attempted. This method was found too costly.

Gerstell (1937) studied the restocking program and pointed out that there was no relationship between the number of cottontails released and the number killed, and that the most favorable effect of these releases was simply a psychological one. Once started, there was an ever-increasing demand for more and more restocking. However, Gerstell did not eliminate restocking from his suggested management program. He recommended the development of food and cover generally, but also suggested intensive development of certain areas from which large numbers of cottontails could be trapped annually for transferring to open hunting land.

Cottontail management in Pennsylvania has followed these lines. Improvement of food and cover has been undertaken on Cooperative Farm Game Projects and State Game Lands, and in recent years cottontails for restocking haves been live-trapped from residential, institutional, military and other areas closed to hunting. Certain tracts have been more or less intensively developed as propagation areas to supply native cottontails for transfer.

The futility of restocking cottontails was described further by

Latham (1952), who again appealed for the improvement of habitat on areas where the hunters could harvest the cottontails. As a result of the many years of rabbit liberations, the sportsmen have grown to expect this service and have not been easily convinced that it should cease. Mainly as a public relations gesture, the Pennsylvania Game Commission has continued the program through the transfer of native cottontails.

The research studies to be discussed here concern the effects of food and cover improvements on cottontail numbers and an appraisal of the program of trapping and transfer of native cottontails. These studies were designed to provide facts upon which game authorities could plan a second cottontail management program.

TRAPPING AND TRANSFER OF NATIVE COTTONTAILS

The cottontail trapping and transfer program was initiated to supply rabbits of better quality and at less cost than those imported from western states. Because transferred animals were confined for only a short period, and not subjected to marked changes in environment, they were assumed to be better able to become acclimated and survive in the new territory. This assumption was confirmed by Langenbach and Beule (1942). They studied the survival of imported and transferred cottontails and reported a known loss prior to the breeding season of 20 to 25 per cent of the imported animals as compared to 5 to 7 per cent for the natives. These investigators worked with comparatively small numbers of animals. Recent and more extensive studies of imported rabbits by Dell (1953) revealed much heavier losses prior to the breeding season.

When the Pennsylvania Game Commission ceased importing cottontails, the program of trapping and moving native cottontails was enlarged. During the last three years the average annual transfer has been about 56,000 cottontails. Primarily, these rabbits were transferred with the intent of replenishing the breeding stock and to give relief to nurserymen, orchardists, and homeowners experiencing damage to trees, shrubs, and crops.

To many sportsmen, this program has appeared to be a successful means of producing more rabbits, and they believe it should be even further expanded. Certainly 56,000 cottontails liberated over twenty million acres of habitat can hardly make a large contribution to the total population. And there is little likelihood that it would be economically possible to provide the large numbers of cottontails wanted by sportsmen, even if it were a desirable management procedure. The usual counter by sportsmen to the statement that these rabbits cannot logically improve the statewide picture is that they released rabbits in certain localities and the population increased. Usually the increase is mere supposition, because they do not know the density of rabbits prior to or following the releases, and they have no evidence that the numbers they report would not have existed without the releases.

Observations of numerous release areas did not reveal any relationship between the number released and the populations of the following fall. On a sportsmen's club property in western Pennsylvania, the release of 129 imported cottontails on 96 acres in January was followed by a low population in the fall. These men complained bitterly and decided against further importations but requested that native animals be transferred to the property. Sixty tagged and marked native cottontails were released on their grounds and again there was no improvement in the cottontail popuation the following fall. This club is now convinced that they must improve their grounds if they want more rabbits.

Another club imported about 240 cottontails annually for four successive years to restock a dog training area of 210 acres. Despite the fact that this area was closed to hunting, the rabbit numbers remained low. This club has recently embarked on a habitat improvement program and has been well pleased with the early response by cottontails. Many additional examples demonstrating the failure of native rabbits to improve populations could be cited.

The study of the trapping and transfer program was begun early in 1952 in three locations. Altogether 1,614 cottontails were sexed, tagged and marked prior to liberation during that year. Examination of some of the release areas during the weeks immediately following liberations resulted in few observations of the marked animals. Other persons observed marked animals several miles from the nearest release point.

A rather broad variation was experienced in the recoveries from the three areas. In western Pennsylvania 11 tag returns from road-killed animals were received prior to the hunting season and 33 rabbits were reported killed during the season from the total of 1,054 tagged. A year later, in the 1953 season, two tagged rabbits were reported by hunters and one was killed on a highway. These animals had traveled distances up to ten miles from the release points and one returned three-fourths of a mile to its original home. Kill locations were obtained for 24 of the 33 hunting returns, and the distances these animals traveled from the release sites are listed in Table 1.

These returns showed that many rabbits failed to stay near the liberation sites, which in most cases were selected for their apparent suitability for cottontails. Some of these rabbits were released at night,

TABLE 1. RECOVERY DISTANCES OF TRANSFERRED COTTONTAILS, 1952 HUNTING SEASON—WESTERN PENNSYLVANIA

Distance	No. of animals
Vicinity of release	3
Under ½ mile	6
½ to 1 mile	6
1½ miles	3
2 miles	3
3 miles	1
5 miles	1
10 miles	1

and apparently the survival of night-released rabbits was better than those released in daylight. Cottontails in superior physical condition, trapped from areas of good food, were better represented in the returns than were those from poorer sites.

Of the 206 rabbits transferred in central Pennsylvania, there were seven road-killed animals reported during a short period following liberation. Ten months following release a cottontail was found dead at a point four miles removed from the release site. During the first hunting season, hunters reported two tagged rabbits, each taken about one mile from the point of liberation. In the second season, one rabbit was reported killed. Twelve of the 354 rabbits tagged in northeastern Pennsylvania were reported killed by hunters during the 1952 season and one during the 1953 season.

Early in 1953 in northcentral Pennsylvania, 852 cottontails were tagged prior to liberation, and 38 recoveries were reported during the November hunting season. The recovery distances for the animals reported from the 1952 and 1953 releases in northeastern and northcentral Pennsylvania are listed in Table 2. Locations of recovery were reported for 52 cottontails.

During January and February, 1953, 2,035 cottontails were transferred from Letterkenny Ordnance Depot in Franklin County to open hunting areas in southcentral Pennsylvania. These rabbits were sexed and ear tagged and about one-third of them were marked for field identification. Also, 134 cottontails from other sources were sexed,

TABLE 2. RECOVERY DISTANCES OF TRANSFERRED COTTONTAILS, 1952-53—NORTHEAST AND NORTHCENTRAL PENNSYLVANIA

Distance	No. of animals By hunting	Other
Under ½ mile	23	10
½ to 1 mile	3	7
1½ miles	1	....
2½ miles	2	....
4 miles	2	....
5½ miles	1	....
8 miles	2	....
12+ miles	....	1

tagged and marked at the same time. There were only six road kills reported for the 2,035 cottaintails transferred from the Ordnance Depot. One of these animals had traveled 8½ miles from the point of release.

Extensive newspaper publicity was given the tagging project just prior to the 1953 hunting season. Sixty-nine of the 2,035 cottontails were reported killed by hunters and the location of kill was obtained on 61 of these. In contrast to western Pennsylvania, many of these animals were reported killed near the release sites (Table 3).

As a check on returns and to acquire further information on transferred animals, 100 tagged cottontails were released in October about four weeks prior to the 1953 hunting season on the same area where 62 had been released during January and February 1953. Only three of the 62 released in January and February were reported killed, but 23 of the 100 liberated just prior to the open season were reported. The return of 23 per cent of October released cottontails compared favorably with McDowell's (1952) 25 per cent return in another part of Pennsylvania for fall-released rabbits. These returns suggest that the bulk of the recoveries are reported and that the kill of winter released cottontails is indeed small.

To investigate further the behavior of transferred animals and their homing tendencies, cottontails were tagged, marked and moved various distances. With the exception that some rabbits homed from the shorter distances up to three miles, the results generally indicated that it made little difference whether the rabbits were moved ½ or 50 miles. In any case, few of the animals remained where stocked.

Various factors appeared to influence the survival and travels of transferred animals. The time of release—daylight or darkness—and the physical condition of the liberated animals were mentioned previously. When released on snow the transferred animals experienced greater difficulty in becoming acclimated to the new surroundings. The existing cottontail population and the available food and cover of the release area were extremely important factors.

An increase in the amount and value of information on the transfer of cottontails should be realized in the coming year. Nearly 7,000 cot-

TABLE 3. RECOVERY DISTANCES OF TRANSFERRED COTTONTAILS, 1953 HUNTING SEASON—SOUTHCENTRAL PENNSYLVANIA

Distance	No. of animals
Vicinity of release	44
Under ½ mile	8
½ to 1 mile	5
2 miles	2
3 miles	2

tontails were tagged during the transfer operations recently completed.

HABITAT IMPROVEMENT AND COTTONTAIL NUMBERS

Extensive efforts have been put forth by many states to improve cottontail habitat, but little attenion has been devoted to evaluating this work in terms of cottontail increase or recreation provided for sportsmen. In Pennsylvania much of this habitat improvement work has been carried out on abandoned farm lands. In the southwestern part of the state on land of this character, a study was undertaken to determine practical methods of improving these lands for cottontails and the effect of these environmental changes on the cottontail population. This study was financed under the Federal Aid in Wildlife Restoration Program, as were two companion studies in northwestern and northeastern Pennsylvania. All projects were completed in four to five years, but observations of vegetative and population changes have been continued since their termination.

Game Lands No. 203, located in Allegheny County near Pittsburgh, was selected for the study area in southwestern Pennsylvania. Poverty grass (*Danthonia spicata*), dewberry (*Rubus flagellarius*), and broomsedge (*Andropogon scoparius*) were common over a large part of the abandoned fields. Extensive thickets and stands of crabapple (*Malus coronaria*), aspen (*Populus tremuloides*), red maple (*Acer rubrum*), sassafras (*Sassafras albidum*), black locust (*Robinia pseudoacacia*), and Virginia pine (*Pinus virginiana*) were also common. Of the 1,250 acres in the tract, about 40 per cent had been farmed in the past and 60 per cent is woodland.

Two similar, 300-acre areas separated by a wide, wooded buffer strip were selected. One was designated the control area, and the other the management area where the food and cover development work was done. Neither area was subjected to predator control. Rabbits were live-trapped and tagged at regular intervals on both areas to follow the trends in cottontail numbers. During the hunting seasons, hunters were interviewed and questionnaires were distributed to gather information on hunting effort and success.

Food and cover improvements were undertaken on about 40 of the 300 acres in the experimental tract. Altogether 48 food plots and 17 cover improvement plots were established. Food plots ranged in size from 0.06 to 1.1 acres and embraced about 14.25 acres. Generally the plots were long, narrow strips established immediately adjacent to existing cover or to areas upon which cover could be improved. Preparation of the plots involved plowing and/or disking and the application of pulverized agricultural limestone and commercial fertilizers.

A variety of grass-legume mixtures was tested. Initial legume stands were generally poor because of soil conditions, but, nevertheless, some desirable cottontail food was produced. As the soil condition was improved by the lime, fertilizer, and legume growth, the subsequent seedings were much improved. Where the fertility level was raised sufficiently, bluegrass (*Poa pratensis*) and white clover (*Trifolium repens*), both highly desirable cottontail foods, often volunteered.

Cover improvement was accomplished mainly by cutting woodland edges, old fencerows, and other areas. The cut brush combined with the new vine, shrub and brier growth, produced good quality cover. The 17 plots of this type embraced about 26 acres. Various herbicides were used experimentally to determine their value in controlling undesirable growth which threatened to cut short the beneficial period of these plots. These chemicals showed considerable promise in the manipulation of cover.

Cottontails responded quickly to the food and cover improvements. The improvement work was begun early in 1949, and for the most part was completed early in 1951. A trap line of permanent trap sites was established on each area in the fall of 1948 prior to any food or cover improvement. During the three years following the initial trapping there was an annual increase in the number of cottontails on the managed area, while on the control area the numbers varied slightly above and below the initial population. The numbers of cottontails were computed from capture and recapture data and observation of and recovery of marked animals. Fall populations for each area are listed in Table 4.

The increase in the number of cottontails on the managed area resulted from the increased survival of young cottontails, and it appeared that the provision of desirable summer food was an important factor in the increased survival. Beule (1946) in writing of summer foods of cottontails stated that although sufficient food was to be found in most habitats, cottontails were found most abundant where certain preferred foods existed. He also stated that young cottontails appeared to live almost entirely on these preferred foods for about a month after leaving the nests. Summer cover appeared to be an im-

TABLE 4. FALL POPULATION OF COTTONTAILS

Year	Management Area	Control Area
1948	88	80
1949	168	91
1950	210	61
1951	288	106

portant factor in increased survival, and it was apparent that the greater yield of cottontails was largely dependent upon favorable juxtaposition of summer food and cover.

The amount of hunting season recreation and the cottontail kill increased with the habitat improvement. Hunting pressure in 1951 was more than triple that of 1948, and three to five times as many cottontails were taken in the final three years of the study as were killed in 1948. Prior to 1949 this area was used little for dog training purposes, but subsequently it became a popular site for this activity.

Despite the heavy hunting pressure on this area, there was adequate survival of cottontails to provide for the increases which occurred during each succeeding year. The number of tagged rabbits reported killed never exceeded 20 per cent of those tagged just prior to the hunting season. Observations and trapping following the hunting season indicated that the cottontail harvest could have been much heavier.

Cost of the improvement work was rather high, partly because much of the work was of an experimental nature. In actual practice and with the experience and information gained, the cost would be much reduced. The additional recreation provided can hardly be tagged with the dollar sign, but there are some persons who continue to condemn food and cover work as being too costly. The few cottontails killed on these Game Lands prior to any improvement work, and on the control area during the study, certainly revealed the value of habitat improvement. It must be recognized that to improve long abandoned land for game requires heavy expenditures during the developmental phase, but the costs of maintenance should be relativly light if planning has been sound.

Some criticism of food and cover work is justified, but has resulted from poor judgment, a lack of information, or incapable supervision. Thus, some beagle clubs and sportsmen's club have almost lost interest because the food plots they estabilshed far from cover, or the small brush heaps which disintegrated in a season, failed to produce the desired results quickly. More thorough planning and qualified supervision of the habitat improvement work will be required if this criticism is to be avoided.

DISCUSSION

While the importance of food and cover to game production is well recognized by biologists, many of the disagreements concerning management between the Pennsylvania Game Commission and sportsmen of the State have stemmed from a lack of understanding of this fundamental relationship. If these differences are to be avoided, biologists must become better salesmen and teach these basic principles to the sportsmen and to other employees of their game agency as well.

Probably one of the most striking examples of the effect of food and cover on cottontails in Pennsylvania occurred on the Letterkenny Ordnance Depot. Prior to its adoption by the U. S. Army, this area of above-average farm land supported low game populations as does much of the surrounding farm land today, primarily because of poor cover conditions resulting from intensive farming operations. When farming operations ceased, there was a tremendous increase in the number of cottontails. Predators also increased markedly. Foxes were abundant until disease controlled them. Large numbers of hawks concentrated on the area and feral house cats were numerous, but the cottontail population continued high. Annually several thousand cottontails were removed for restocking purposes. Certainly here lies ample proof of the role of food and cover in rabbit management. No rabbits were liberated on the area, and the large numbers of predators did not prevent their increasing to almost unbelievable numbers. Other areas in the state have been trapped annually and many rabbits removed—certainly a larger share of the population than is normally harvested by hunters on open hunting areas. This annual removal of large numbers of rabbits has continued without restocking.

One of the chief factors affecting the hunting season harvest of cottontails in Pennsylvania in recent years has been the seemingly ever-increasing tendency of cottontails to spend the daylight hours underground in woodchuck burrows. While thus concealed, rabbits are not available and, as far as the hunters are concerned, there are none. Over much of the intensively cultivated farm land, burrows are about the only available protection for rabbits, but this denning is not restricted entirely to the poor cover areas. However, because cottontails do frequent burrows and are protected during the hunting season, adequate numbers survive to breed and satisfy the carrying capacity of the available coverts.

Probably the main argument presented by those in favor of restocking is that since it is difficult to carry out habitat improvement work on intensely cultivated farmland and to improve enough areas statewide, then we must release rabbits annually to replenish the breeding stock. All of our studies indicate that this replenishment is unnecessary, and the released rabbits seldom succeed for the same reasons that limited the population in the first place.

SUMMARY AND CONCLUSIONS

As Pennsylvania's chief small game species, the cottontail rabbit has been under some type of management for many years. Habitat improvement has been attempted but the appraisal of the practices involved and the results obtained have often been neglected. For many years the Pennsylvania Game Commission imported cottontails for restocking and upon discontinuing this practice several years ago has encouraged a program of trapping and transfer of native cottontails.

Food and cover improvement practices on a tract of abandoned farm land in western Pennsylvania induced a highly satisfactory response by cottontails. Although only about 40 acres of a 300-acre study area were developed, in three years the population tripled. At the same time cottontail numbers on the control area varied slightly above and below the initial numbers. The increase on the managed area was reflected in the hunters' bag, which was 3 to 5 times the bag of the year preceding the initiation of improvements. Despite extremely heavy hunting pressure, the largest return from cottontails tagged just prior to the hunting season was about 20 per cent. Post-hunting-season trapping and observations indicated that a larger harvest could have been enjoyed without endangering future harvests.

The annual transfer of native cottontails for restocking purposes appeared to be the solution to the cries for more rabbits. Despite observations that adequate numbers of rabbits survived the hunting seasons, sportsmen have demanded annual liberations. They insist that cottontails must be liberated following the hunting season to insure breeding stock and rabbits for the next season.

Reported hunting season recoveries of tagged, transferred cottontails have amounted to about four per cent of those released. This low recovery rate during the hunting season, the few marked animals observed following liberation, and the observation of comparable populations on stocked and unstocked areas suggest that losses are extremely heavy immediately following release and that the liberations are not fulfilling the intended purpose.

Perhaps the initial requirement for more effective cottontail management (actually all game management) in Pennsylvania is education of the sportsmen and the public. Undoubtedly the best education is experience, and perhaps the goal of education could be attained most quickly if game departments would courageously abandon non-productive management methods and employ those practices which foster the conditions indispensable to good game populations.

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WILDLIFE HABITAT DEVELOPMENT AT RESERVOIRS

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The theme of this conference, "Natural Resources—whose responsibility?", is closely related to the activities of construction agencies in building water-development projects. Almost inevitably there are conflicts when one agency seriously affects wildlife resources in the process of developing land and water resources. I would like to discuss responsibilities, under federal law, for the replacement of upland-game habitat in connection with water-use projects throughout the country.

Secretary of the Interior Douglas McKay has said, "The Department of the Interior, under my administration, considers the protection and development of our fish and wildlife resources to be as essential as irrigation, flood control, and navigation in river-development projects." Such a statement points up the opportunities which many of us in the field of conservation are responsible for implementing.

The Coordination Act of August 14, 1946, or Public Law 732 as many of you know it, assigned to the Fish and Wildlife Service the responsibility for carrying out investigations to determine the effects, on fish and wildlife, of federal water-use projects designed primarily for flood control, irrigation, power, and navigation. These are projects planned by such agencies as the Corps of Engineers, the Bureau of Reclamation, bureaus in the Department of Agriculture, or private power companies operating under Federal Power Commission license. In the investigations, the Service, through the Office of River Basin Studies, cooperates closely with the States. In the past eight years, we have prepared reports on about 1,400 such projects.

Water-development projects can be beneficial as well as harmful to wildlife. Upland game, with which this paper is primarily concerned, is usually benefited when lands are placed under irrigation, but losses generally result when valuable bottom lands are flooded by reservoirs.

Loss of extensive wildlife habitat within the Oahe, Garrison, Fort Randall, and Gavins Point Reservoirs being built on the Missouri River in North Dakota, South Dakota, and Nebraska, is a case in point. When these reservoirs are completed, more than 875,000 acres of bottom-land habitat will be flooded at maximum normal operating pool.

The Coordination Act provides for measures to prevent loss of or damage to fish and wildlife resources which may be caused by federal water-use projects, and for making publicly owned project lands available to the states or the Fish and Wildlife Service for wildlife-management purposes. The costs of measures to prevent or mitigate damages are chargeable to the project. Under a Bureau of the Budget directive issued 15 months ago, the costs of measures to *improve* or *enhance* fish and wildlife resources at federal water developments are to be borne by the state or local government or by private interests, or by the Federal Government when there are wildlife values determined by the Secretary of the Interior to be of national significance. Many of the state conservation departments have for some time been carrying out with their own funds rather extensive programs of waterfowl and upland-game habitat development on existing reservoirs.

If a reservoir will result in losses to wildlife, a mitigation measure might involve food and cover replacement development for upland game. This is particularly desirable in arid or semi-arid regions of the West where the best habitat for many species is in the bottomlands. It is impossible, however, to replace lost habitat acre for acre on projects. If plantings are recommended, a wildlife habitat development report is prepared, outlining planting proposals and costs. This is followed by detailed plans and specifications for the planting program. All habitat work is planned cooperatively by the Service and the state conservation department. It should be pointed out that planted areas may be only a small part of a large management unit embracing an extensive portion of the reservoir area. If the state will assume responsibility for operation and maintenance of development units after their completion, a request is made to the construction agency that necessary funds be obtained to carry out the work.

To obtain control of lands for wildlife, the procedure on a Corps of Engineers project involves first the preparation of a three-way General Plan in accordance with the directive of the Coordination Act, among the Secretary of the Army, the Secretary of the Interior, and the State conservation department. On Bureau of Reclamation projects, the General Plan is approved by the Secretary of the Interior and the state conservation department. If the area is of particular value in carrying out the national migratory bird management program, the lands may be made available to the state by the Department of the Interior under a cooperative agreement; otherwise the use agreement—which is a separate document from the General Plan required by the Coordination Act—is directly between the state and the constructing agency. The agreement empowers the state to supervise and manage the wildlife resources of the area.

An agreement was recently completed between the Idaho Power Company, the Idaho Fish and Game Department, and the Department of the Interior for wildlife management of lands within the C. J. Strike Reservoir on the Snake River. This is the first agreement between a private power company and government agencies in which the company's lands were made available to the state for wildlife management under the Coordination Act. That agreement recognized that wildlife losses should be compensated for insofar as possible, and maximum wildlife benefits should result.

BUREAU OF RECLAMATION PROJECTS

The Bureau of Reclamation estimates that pheasant hunters in 1951 spent 170,000 hunter-days on 19 reservoir projects, including irrigated lands, and that approximately 300,000 hunter-days were spent in all types of hunting on these projects (United States Bureau of Reclamation, undated). Federal wildlife refuges developed for waterfowl cover a considerable acreage on Bureau projects, but over 147,000 acres of land acquired at 14 reservoirs have been transferred to the states. Negotiations are also under way for lease of approximately 14,000 additional acres of land to the states. Much of this area is for upland-game management.

Some of the areas under lease to the states from the Bureau include Bonny Reservoir in Colorado; Canyon Ferry Reservoir in Montana; Enders Reservoir and Swanson and Harry Strunk Lakes in Nebraska; Heart Butte Reservoir in North Dakota; Shadehill Reservoir in South Dakota; and several areas in the Columbia Basin Project in Washington. These projects include plantings financed with Bureau funds, but substantial Federal Aid funds also have been obligated on some of the developments.

The Bureau of Reclamation has cooperated closely with the Service and the states in the habitat-restoration program in the Missouri River Basin. At eight Bureau projects, 101 habitat replacement sites are nearing completion. These include establishment of approximately half a million trees and shrubs. Since inception of the program, expenditures by the Bureau for fencing, planting, cultivation, and replacement have totaled $167,000, and the estimated total cost for these measures on the eight projects is approximately $220,000. In addition, the states have made substantial expenditures.

A habitat replacement program for upland game at federal reservoirs in the Great Plains States usually includes tree and shrub plantings suitable primarily for winter cover, together with herbaceous plantings for food and nesting. Areas are generally fenced for protection from grazing, and these usually vary in size from 5 to 10 acres, although many cover several hundred acres and involve merely fencing for protection from grazing. Ground is prepared in the fall for spring planting, and there is a standard arrangement of food and cover plants in relation to prevailing winds. Plantings are a minimum of 300 feet in width and must be adjacent to available food. Replanting and cultivation are usually carried out by the constructing agency over a period of 3 to 5 years in order to assure establishment of the plantings. Development and preliminary maintenance by the constructing agency is sometimes done under contract and occasionally by force account.

The Enders Reservoir constructed by the Bureau of Reclamation on Frenchman Creek in southwest Nebraska represents a somewhat typical wildlife-habitat development in the Great Plains. This is in the semi-arid, short-grass plains region where the proper balance of upland-game habitat usually occurs in the valleys, and where relatively high populations of game are found in the mixed grassland, cropland, and timberland. The Enders Reservoir permanently floods 1,700 acres of such habitat and seasonally floods another 735 acres.

To compensate for as much of the lost upland-game habitat as possible, the replacement measures planned for Enders Reservoir consist of developing a 230-acre seep area downstream from the reservoir, and a 660-acre unit at the upper end of the reservoir. The latter includes hedges connecting areas of food and cover, plantings of trees and shrubs for winter cover, fencing of the entire area, and development of a 6-acre marsh. In addition, a series of seven sites, of seven acres each, is being developed along the margins of the reservoir. Trees and shrubs have been planted, and each unit is protected from livestock. The Nebraska Game, Forestation and Parks Commission is now managing the wildlife areas.

In addition to the basic or minimum habitat development described above, the Bureau of Reclamation has arranged for several state conservation departments to administer and manage most of the remaining government-owned lands of the reservoir areas. These areas are usually extensive and are to be managed according to land-use capabilies and good soil conservation practices. The basic wildlife development can thus be well integrated into the over-all reservoir management. Lands of certain Bureau reservoirs in Colorado, Nebraska, North Dakota, and South Dakota, are being administered under such an arrangement.

CORPS OF ENGINEERS PROJECTS

Approximately 800,000 acres of land and water in 25 states have been made available for recreational purposes on 75 project areas under jurisdiction of the Corps of Engineers. The Corps estimates that in 1951 about 775,000 man-days of hunting took place in these areas (United States Senate, 1952). About 12 per cent of this total area is being administered by the Fish and Wildlife Service for the national migratory bird management program, but state wildlife-management units, many of which are developed primarily for upland game, total about 325,000 acres at 32 of the projects. Licenses from the Corps to the states under authority of the Flood Control Act of 1934 are for "recreational" purposes, but some recent land control transfers have been made under authority of the Coordination Act. At most Corps projects funds for development and management have thus far been provided by the states, usually through the Federal Aid program, and over $500,000 have been obligated thus far on such projects.

Game management areas on reservoirs of the Corps of Engineers vary considerably in size. Typical projects involving waterfowl as well as upland-game habitat include the 4,000-acre Birch Hill Reservoir now under a 25-year lease to the Massachusetts Department of Conservation. In New Hampshire, the Fish and Game Department is developing 1,030 acres at the Edward MacDowell Reservoir, while West Virginia's lease with the Corps at the Bluestone Reservoir covers 19,866 acres. The Oklahoma Game and Fish Department has areas totaling about 40,000 acres under lease at Fort Gibson, Fort Supply, Wister, and Canton Reservoirs. At the latter reservoir it was estimated that 2,000 bobwhite quail, 1,500 rabbits, and 1,000 fox squirrels were harvested in 1951. Arkansas has planted bicolor lespedeza on 115 one to two-acre plots at the Blue Mountain Reservoir, and 114 similar plots at the Nimrod Reservoir. At the Baldhill Reservoir (Lake Ashtabula) in North Dakota, approximately 450,000 trees and shrubs were planted, and 14 miles of fencing were constructed. Lands for wildlife management have also been leased to Delaware along the Chesapeake and Delaware Canal right-of-way, to Connecticut at Mansfield Hollow Reservoir, to Georgia at Clark Hill Reservoir, and to West Virigina, Pennsylvania, Ohio, and Kentucky at the Tygart, Loyalhanna, Delaware, and Dewey Reservoirs respectively.

Negotiations are now under way for transfer of lands to the states under provisions of the Coordination Act on approximately 77,000 acres within Corps of Engineers projects. These areas include Fort Randall Reservoir in South Dakota, where $74,000 has been allocated for habitat replacement in fiscal year 1954, and the Garrison Reservoir in North Dakota, where $63,000 has been set aside for similar work. It is contemplated that the work at both areas will be done on contract with the State Conservation Departments. Other projects include Gavins Point Reservoir in South Dakota and Nebraska, Orwell Reservoir in Minnesota, Cheatham Lock and Dam in Tennessee, Demopolis Lock and Dam in Alabama, John H. Kerr Reservoir in North Carolina and Virginia, Conemaugh Reservoir in Pennsylvania, San Angelo and Dam "B" Reservoirs in Texas, and Albeni Falls Reservoir in Idaho. Planning was initiated by the Arkansas Game and Fish Commission for development and management of a proposed 2,000-acre upland-game area on the Bull Shoals Reservoir. There are also a number of areas within the upper Mississippi Locks and Dams which will be managed by the States of Missouri, Iowa, Illinois, Minnesota, and Wisconsin which are in addition to units already under management by these states. Most of these projects will be developed primarily for waterfowl, but many will include upland-game habitat improvement.

GENERAL OBSERVATIONS ON ESTABLISHMENT AND UTILIZATION

It has been our experience that plantings on public lands within the Missouri River Basin can be designed specifically to meet the needs of wildlife. This is costly, however, in comparison with planting programs now being conducted so successfully by the North Dakota and South Dakota Conservation Departments on private lands where cultivation is done by the landowner at no cost to the states. Plantings should be designed to be established in the least possible time, to require a minimum of maintenance, and to be as permanent as possible. The use of closely spaced, lower-growing species is recommended to facilitate establishment and reduce maintenance. Extensive use of evergreens is recommended to give permanence to the plantings. Close field supervision during the cultivation period is the key to successful establishment (Scott, 1951).

Although the habitat plantings made at water-use projects are not yet fully developed, there is considerable evidence that pheasants use of the herbaceous cover for nesting and the trees and shrubs for winter cover. Mourning doves are also using the trees for nesting, and deer have been observed at some of the sites. Follow-up studies on food and cover plantings now being conducted by many of the great plains states to determine utilization by wildlife should do much to establish future guides for this type of development. We are confident that the plantings will result in making the individual reservoir areas more productive of wildlife and more attractive to sportsmen and recreationists. Such developments are all the more important because they have been established on areas available for free use by the public.

"Natural Resources—whose responsibility?" In the final analysis, wildlife is everbody's business. In particular, the Corps of Engineers and the Bureau of Reclamation, as well as the Federal Power Commission, the Soil Conservation Service and other construction agencies all have responsibility, under law, for fish and wildlife conservation, just as the Fish and Wildlife Service and the state conservation departments.

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DISCUSSION

DISCUSSION LEADER MOHLER: Thank you, Dr. Eklund. We are ready for questions and comments and discussion. There has been a great deal of interest in this kind of work in the last several years in the region Carl refers to.

MR. BERNARD DAWSON (South Dakota): I would like to ask what effect the recent change in policy will have on the habitat development of the reservoirs?

DR. EKLUND: Well, that has given us considerable concern. Perhaps I had better go a little bit into the history of that. Back in October, the Secretary of the Army and the Secretary of the Interior came up with a habitat policy, an order which said, no title of the land will be required for the purposes of wildlife development, unless specifically authorized by Congress.

Well now, that was a rather serious thing, because it means this—land that you could now acquire in fee simple would be obtained under flood easement and that eliminates management by the states in these developments.

We were able to get the order amended, however, to read, "except as authorized by law, no private land will be required for wildlife development," and that part which dealt with, unless authorized specifically by order of Congress, was stricken out. To get a special authorization for every private wildlife development is an extremely difficult thing to do. We found apparently a lot of these projects are authorized but not yet constructed, and it goes back to the whole thing of reauthorization.

We believe as amended, that the addition of, except as authorized by law, we interpret it to mean that the Coordination Act would apply, that the land could be purchased. That is, a project in which there are losses of wildlife. If there are no losses resulting from the construction, then it would not apply. But, that is our interpretation of that amendment. Does that answer your question?

MR. DAWSON: Well, not too well. I am still a little doubtful about how much land we are going to have in South Dakota for wildlife on future projects. We were able to get a fair number of habitat developments at Grand Coulee Dam. At Evans Point, it has been so restricted there will be hardly any land available for wildlife. I wonder if that is going to be true in the future?

MR. EKLUND: We can appreciate your problem in South Dakota because you have lost some valuable wildlife habitat. We hope, of course, that the Corps will purchase land in fee simple around the perimeter of the reservoir. Of course in those areas there are considerable losses. Some of the losses will be waterfowl, but you have lost some very valuable deer as well as pheasant range. How the Corps will interpret it, I don't quite know, but I am sure I can't satisfactorily answer that question for you. It is about the best I can do.

TECHNICAL SESSIONS

Tuesday Morning—March 9

Chairman: JAMES R. WESTMAN
Department of Wildlife Conservation, Rutgers University, New Brunswick, New Jersey

Discussion Leader: DAVID H. WALLACE
Oyster Institute of America, Annapolis, Maryland

COASTAL AND MARINE RESOURCES

MIGRATORY PATTERN AND RACIAL STRUCTURE OF ATLANTIC COAST STRIPED BASS

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This study gives the findings of an expanded investigation of racial stocks of Atlantic Coast striped bass, *Roccus saxatilis* (Walbaum), and was an outgrowth of work reported by Raney and de Sylva (1953: 495). Details of the results of the Schaefer-*Salt Water Sportsman* tagging program are also presented. The region covered by the present study of racial stocks greatly extends that of the former work and was made possible by the aid of the U. S. Fish and Wildlife Service, the Sport Fishing Institute, and the cooperation of many investigators to whom we give our thanks. Those who furnished material or otherwise assisted greatly include H. M. Bearse, E. M. Burton, A. J. Calhoun, J. S. Coolidge, J. H. Cornell, R. W. Crawford, J. R. Greeley, J. Grim, E. C. Hayes, Jr., C. Heacox, A. S. Jones, I. M. Jones, E. A. Lachner, H. Lyman, R. Mansueti, W. H. Massmann, J. L. McHugh, C. R. Robins, L. P. Schultz, R. P. Silliman, A. Schwartz, G. B. Talbot, A. H. Underhill, G. F. Walton, J. R. Westman and C. L. Wheeler.

All counts were made by the authors except for two series from the St. Lawrence River, which were furnished by V. D. Vladykov. Counts

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were made on young or yearlings, unless otherwise specified, in a manner described by Raney and de Sylva (1953). Merriman (1941) and Vladykov and Wallace (1952) have reported on previous attempts to identify striped bass stocks. Studies on migration of striped bass include those by Pearson (1933), Merriman (1937 and 1941), Neville (1940), Vladykov (1947), Vladykov and Wallace (1938 and 1952), and Raney (1954) who reported briefly on the migratory pattern of the Hudson race. Other studies of migration are summarized in Raney (1952). Recently Calhoun (1952) published an excellent study on the migrations of California striped bass in the Sacramento-San Joaquin Delta area.

RACIAL STUDIES

The important sources of striped bass are known to be Albemarle Sound, Chesapeake Bay, Delaware Bay and the Hudson River; other populations are valuable for the local sport fishery. It is known that a stock produced at one locality may contribute greatly to a fishery elsewhere along the coast. The study of races of striped bass by Raney and de Sylva (1953) concentrated largely on the Hudson and Chesapeake stocks. Further material is now available and is analyzed for those two waters and samples or data also have been obtained for the St. Lawrence River; Miramichi River, New Brunswick; Shubenacadie River, Nova Scotia; Albemarle Sound, North Carolina and several localities in South Carolina. Samples are still inadequate for many drainages. Further studies are needed and planned on different year classes from the same locality.

Studies of racial stock utilizing fin ray counts were made of young of the 1953 year class from the Hudson River, several tributaries of Chesapeake Bay, and Ablemarle Sound. Counts (Tables 1 to 4) of soft rays of dorsal, anal, and pectoral fins and a character index which consists of the sum of these counts, continues to give a high percentage (70 per cent of separation between upstream Hudson and Chesapeake stocks. While this result is less than the 81 per cent separation found for previous year classes, especially that of 1949), it is still a relatively high level of differentiation which probably justifies a continued designation as Hudson and Chesapeake races. The counts for 1953 samples were generally lower than those of previous years. The use of fin ray counts in separating stocks is most useful when young bass of the same year class are compared.

Pectoral fin counts are apparently not as useful as was indicated earlier in the studies and several stocks of the 1953 year class showed unexpectedly low counts with rather large variation. Pectoral fins also have been noted to be abnormal in several samples of adults and occasionally were partially destroyed so that an accurate count was difficult or impossible to obtain.

For the samples available before 1953, pectoral rays, of all the single characters, gave the most consistent and highest percentage of separation. It is still true that Hudson race samples are separable from Chesapeake race samples using pectoral counts from the same year class but low counts from young of the 1953 year class from the Rappahannock and the Patuxent rivers indicates that perhaps this character may be modified to a considerable degree by changing physical conditions. It may also be that subraces, low in pectoral ray counts, exist in the upstream reaches of these rivers.

Dorsal ray counts, which in earlier studies seemed to vary in a more erratic manner, gave the most consistent separation for the two main stocks under consideration; mode for Hudson 11, for Chesapeake 12. A reexamaination of samples of ten or more specimens from a locality indicates that this difference holds consistently. An examination of dorsal counts in Table 1 shows that the Hudson race (Haverstraw and upstream stations) have low counts; more often 11 than 12 while the reverse is true for the stock present downstream from Haverstraw, New York and elsewhere. The most southern samples from South and North Carolina and a far north sample from Nova Scotia are highest in dorsal counts. It is of interest also that the extreme geographical samples (Carolina *vs.* Nova Scotia) are very high or highest in anal ray counts. An index combining these two counts separates a high percentage of these populations from most others.

In general anal rays are less likely to show geographic trends which can now be interpreted as significant. However they seem to be of value in delimiting certain subraces as illustrated by the counts for Nova Scotia in Table 2.

Further evidence of the presence of different stocks within a drainage system, such as Chesapeake Bay, was found, but a relatively low level of differentiation was indicated. Those from the James River system continue to show low counts in contrast with the high counts found in adjacent York River. An indication of an upstream and a downstream population in some rivers such as the Rappahannock is noted. Several year classes from the Hudson River suggest that the Hudson race is an upstream form which apparently is limited to the vicinity of Haverstraw and northward, while a quite different stock, with fin ray counts similar to the James River population of the Chesapeake race, exists in the lower part of the river south of Haverstraw. More detailed studies are necessary to determine the precise status of these subraces.

TABLE 1. NUMBER OF DORSAL SOFT RAYS IN YOUNG AND YEARLING STRIPED BASS. THE COLUMN (%) GIVES THE PERCENTAGE OF SPECIMENS WITH 11 OR FEWER DORSAL SOFT RAYS

Locality and year class	No. of Series	Dorsal rays								
		9	10	11	12	13	14	No.	Mean	%
St. Lawrence R., Neuville, 1944-46	2	....	1	30	69	....	....	100	11.7	31
Miramichi R., N.B., 1952	1	....	10	17	124	1	....	144	11.9	13
Shubenacadie R., N.S., 1922	2	....	....	1	38	....	....	39	12.0	3
Mianus R., Cos Cob, Conn., 1948	1	....	3	23	18	....	....	44	11.3	59
Hudson R., N. Y.										
Coxsackie, 1953	1	....	2	47	15	....	....	64	11.2	77
Athens, 1949	1	1	5	14	3	....	....	23	10.9	87
West Camp to Marlboro, 1949, 52, 53	23	....	5	52	2	1	....	71	11.1	81
Haverstraw and Stony Pt., 1949	5	1	12	70	18	....	1	102	11.1	81
Haverstraw, 1952	3	....	....	10	2	....	....	12	11.2	83
Haverstraw, Sept. 1953	1	....	....	34	35	1	....	70	11.5	49
Haverstraw, 1936	1	....	....	10	20	....	....	30	11.7	33
South Haverstraw, 1953	6	1	....	12	17	....	....	30	11.5	43
Delaware Bay, 1951, 52, 53	3	....	3	50	66	4	....	123	11.5	43
Delaware Bay, 1951	1	....	1	20	42	3	....	66	11.7	32
Delaware Bay, 1952	2	....	2	29	20	....	....	51	11.3	61
Chesapeake Bay System										
Bay N. of Potomac R., 1882-1953	34	....	1	29	155	1	....	186	11.3	16
Patuxent R., 1921-1953	9	....	1	18	70	....	....	89	11.8	21
Potomac R., 1879-1953	28	....	1	49	96	1	....	147	11.6	34
Rappahannock R., 1921-1953	7	....	2	62	151	....	....	215	11.6	30
York R., 1921-1953	31	....	....	61	183	3	....	247	12.2	25
James R., 1878-1953	14	....	2	29	32	3	1	67	11.5	46
Albemarle Sound, N. C., 1880-1953	4	....	....	9	51	....	....	60	11.8	15
Edisto, Ashley & Santee R., S. C. 1938-53	5			1	9	....	....	10	11.9	10

TABLE 2. NUMBER OF ANAL RAYS IN YOUNG AND YEARLING STRIPED BASS. THE LAST COLUMN (%) GIVES THE PERCENTAGE OF SPECIMENS WITH 10 OR FEWER ANAL RAYS. THE NUMBER OF COLLECTIONS FROM EACH LOCALITY IS THE SAME AS GIVEN IN TABLE 1.

Locality and year class	Anal rays										
	7	8	9	10	11	12	13	14	No.	Mean	%
St. Lawrence R., Neuville, 1944-46	....	....	....	21	79	....	....	....	100	10.8	21
Miramichi R., N.B., 1952	1	1	13	61	66	1	1	....	144	10.4	53
Shubenacadie R., N.S., 1922	....	....	....	....	39	....	....	....	39	11.0	0
Mianus R., Cos Cob, Conn., 1948	....	....	....	13	31	....	....	....	44	10.7	30
Hudson R., N. Y.											
Coxsackie, 1953	....	....	1	27	36	....	....	....	64	10.6	44
Athens, 1949	....	....	1	5	14	3	....	....	23	10.9	87
West Camp to Marlboro, 1949, 52, 53	....	....	1	29	41	....	....	....	71	10.6	42
Haverstraw and Stony Pt., 1949	....	....	5	46	51	....	....	....	102	10.4	51
Haverstraw, 1952	....	....	....	3	9	....	....	....	12	10.8	25
Haverstraw, 1953	....	....	....	15	55	....	....	....	70	10.8	21
Haverstraw, 1936	....	....	....	5	25	....	....	....	30	10.8	20
South Haverstraw, 1953	....	....	....	6	24	....	....	....	30	10.2	20
Delaware Bay, 1951, 52, 53	....	....	1	24	97	1	....	....	123	10.4	20
Delaware Bay, 1951	....	....	1	5	59	1	....	....	66	10.9	9
Delaware Bay, 1952	....	....	....	17	34	....	....	....	51	10.7	33
Chesapeake Bay System											
Bay N. of Potomac R., 1882-1953	....	....	....	16	170	....	....	....	186	10.9	9
Patuxent R., 1921-53	....	....	....	10	79	....	....	....	89	10.9	11
Potomac R., 1879-1953	....	....	....	21	125	1	....	....	147	10.9	15
Rappahannock R., 1921-1953	....	....	....	37	177	1	....	....	215	10.8	17
York R., 1921-53	....	....	....	28	219	1	....	....	248	10.9	11
James R., 1878-1953	....	....	....	12	55	....	....	....	67	10.8	18
Albemarle Sound, N. C. 1880-1953	....	....	....	4	56	....	....	....	60	10.8	10
Edisto, Ashley & Santee R., S. C., 1938-53	....	....	....	1	9	....	....	....	10	10.9	10

TABLE 3. NUMBER OF PECTORAL RAYS (BOTH SIDES) IN YOUNG AND YEARLING STRIPED BASS. THE LAST COLUMN (%) GIVES THE PERCENTAGE OF SPECIMENS WITH 32 OR FEWER PECTORAL RAYS. THE NUMBER OF COLLECTIONS FROM EACH LOCALITY IS THE SAME AS GIVEN IN TABLE 1.

Locality and year class	Pectoral rays 27	28	29	30	31	32	33	34	35	36	37	38	No.	Mean	%
Miramichi R., N. B., 1952	....	....	....	....	....	13	14	112	5	....	....	....	144	33.8	9
Shubenacadie R., N. S., 1922	....	....	....	....	....	3	7	25	4	....	....	....	39	33.8	8
Mianus R., Cos Cob, Conn., 1948	....	....	....	1	....	21	12	10	....	....	....	....	44	32.7	50
Hudson R., N. Y.															
Coxsackie, 1953	....	1	3	2	6	47	3	....	1	....	....	....	63	31.7	94
Athens, 1949	....	1	1	3	6	7	2	1	....	....	....	....	21	31.3	86
West Camp to Marlboro, 1949, '52, '53	....	....	3	4	7	30	9	18	....	....	....	....	71	32.3	62
Haverstraw & Stony Pt., 1949	....	....	....	5	10	50	19	17	....	....	....	....	101	32.3	64
Haverstraw, 1952	....	....	....	....	2	4	5	1	....	....	....	....	12	32.4	50
Haverstraw, 1953	....	....	....	3	5	39	11	10	1	1	....	....	70	32.4	67
Haverstraw, 1936	....	....	....	1	3	15	7	4	....	....	....	....	30	32.3	63
South Haverstraw, 1953	....	....	....	....	....	6	9	13	....	1	....	....	29	33.4	21
Delaware Bay, 1951, '52, '53	....	....	2	....	9	29	27	37	15	1	....	....	120	33.1	33
Delaware Bay, 1951	....	....	2	....	7	12	12	18	14	....	....	....	65	33.1	32
Delaware Bay, 1952	....	....	....	....	2	14	14	18	....	1	....	....	49	33.0	35
Chesapeake Bay System															
Bay N. of Potomac R., 1882-1953	....	....	....	5	3	49	25	79	16	7	1	....	185	33.3	31
Patuxent R., 1921-53	....	....	....	5	2	32	16	27	4	1	1	....	88	32.8	44
Potomac R., 1879-1953	....	1	2	2	3	12	31	79	13	2	....	....	145	33.5	14
Rappahannock R., 1921-1953	1	3	4	10	11	61	49	62	5	2	1	1	210	32.7	42
York R., 1921-53	....	....	....	1	5	18	36	124	31	24	2	....	241	33.9	10
James R., 1878-1953	....	....	....	....	3	10	11	35	6	1	1	....	67	33.5	19
Albemarle Sound, N.C., 1880-1953	....	....	....	....	....	26	10	24	....	....	....	....	60	32.9	48
Edisto, Ashley, & Santee R., S. C., 1938-53	....	....	....	....	1	5	1	3	....	....	....	....	10	32.6	60

TABLE 4. FREQUENCY DISTRIBUTIONS OF THE CHARACTER INDEX (SUM OF SOFT RAYS OF DORSAL, ANAL AND BOTH PECTORAL FINS) IN YOUNG AND YEARLING STRIPED BASS. THE LAST COLUMN (%) GIVES THE PERCENTAGE OF SPECIMENS WITH AN INDEX OF 55 OR LESS. THE NUMBER OF COLLECTIONS FROM EACH LOCALITY IS THE SAME AS GIVEN IN IN TABLE 1.

Locality and year class	Character index															
	49	50	51	52	53	54	55	56	57	58	59	60	61	No.	Mean	%
Miramichi R., N. B., 1952	....	....	....	2	4	11	22	50	48	7	....	....	....	144	56.0	27
Shubenacadie R., N. S., 1922	....	....	....	....	....	....	3	8	24	4	....	....	....	39	56.7	8
Mianus R., Cos Cob, Conn., 1948	....	1	....	1	5	10	15	8	4	....	....	....	....	44	54.7	73
Hudson R., N. Y.																
Coxsackie, 1953	....	2	1	3	24	21	10	....	....	1	....	....	....	62	53.6	98
Athens, 1949	1	3	3	2	5	3	4	....	....	....	....	....	....	21	52.5	100
West Camp to Marlboro, 1949, '52, '53	....	3	2	7	11	26	10	6	6	....	....	....	....	71	54.0	83
Haverstraw & Stony Pt., 1949	....	....	7	12	21	28	20	9	4	....	....	....	....	101	53.8	87
Haverstraw, 1952	....	....	....	1	1	4	5	1	....	....	....	....	....	12	54.3	92
Haverstraw, 1953	....	....	....	3	13	15	20	10	8	....	1	....	....	70	54.7	73
Haverstraw, 1936	....	....	....	2	2	5	14	4	3	....	....	....	....	30	54.8	77
South Haverstraw, 1953	....	....	1	1	1	5	5	6	11	....	....	....	....	30	55.5	43
Delaware Bay, 1951, '52, '53	....	....	1	1	11	20	26	25	25	10	1	....	....	111	55.7	45
Delaware Bay, 1951	....	....	1	....	4	12	9	12	17	9	1	....	....	65	55.8	40
Delaware Bay, 1952	....	....	....	1	7	7	16	10	7	1	....	....	....	49	55.0	63
Chesapeake Bay System																
Bay N. of Potomac R., 1882-1953	....	....	....	....	8	11	51	27	67	16	5	....	....	185	56.1	38
Patuxent R., 1921-53	....	....	....	....	7	10	31	15	21	3	1	....	....	88	55.5	55
Potomac R., 1879-53	....	1	3	1	3	10	23	37	55	11	1	....	....	145	56.0	28
Rappahannock R., 1921-53	....	2	2	9	15	26	50	50	45	4	2	1	1	207	55.3	50
York R., 1921-53	....	....	....	1	3	6	34	56	88	29	22	1	....	240	56.7	18
James R., 1878-1953	....	....	....	2	1	4	15	21	18	4	2	....	....	67	56.0	33
Albemarle Sound, N. C., 1880-1953	....	....	....	....	1	5	21	14	19	....	....	....	....	60	55.7	45
Edisto, Ashley & Santee R., S. C., 1938-53	....	....	....	....	....	1	6	1	2	....	....	....	....	10	55.4	70

The Delaware stock seems somewhat intermediate but falls close to the Chesapeake race on the character index. There is considerable difference in some counts between the two year classes (1951 and 1952) which are adequately represented. Almost all Delaware specimens were taken at the end of their second summer and perhaps represent slightly different stocks, one of which is perhaps an upstream form. Study of additional samples over several years may clarify this problem.

The Albemarle Sound population is similar to the Chesapeake race in fin ray counts but the rather compact distribution gives further indication that these bass are an endemic group. Previous scanty returns from tagging reported by Merriman (1941) imply the same conclusion.

The small sample from the Edisto and Santee rivers, South Carolina, is similar to the geographically adjacent population of Albemarle Sound, North Carolina, in dorsal and anal counts. However, the South Carolina population has a low pectoral count and a low lateral line scale count (Table 5) which permits almost a 100 per cent separation and indicates a considerable degree of endemism for this stock.

TAGGING PROGRAM

The returns from the Schaefer-*Salt Water Sportsman* tagging program were made available by Henry Lyman. This project was begun in 1948 with the cooperation of the membership of various bass fishing clubs. The object was to encourage fishermen to tag as many bass as possible, and 9,320 were tagged through 1952 at which time the project was terminated. Yearly prizes were offered to clubs and to individuals tagging the greatest number, but no rewards were given for returned tags. Tagging was done in the region from Massachusetts to Chesapeake Bay, but most was in the western quarter of Long Island Sound where about two-thirds were tagged. In the vicinity of Greenwich, Connecticut, Edwin W. Morrell was especially active and during one year (1951) affixed more than 1,000 tags.

The tags used were Peterson discs of red and white vinylite 0.5 inch in diamater, 0.020 in thickness, with a center hole .040 inch in diameter. On the white tag was printed "Schaefer Tag No." followed by a serial number; on the red "*Salt Water Sportsman* Return Both Discs Boston, Mass." The pins were number 20 gauge, .032 inch in diameter and 1.625 inches long. The first used were of pure nickel although later pins were a nickel alloy. The tags were affixed by piercing the posterior caudal peduncle just anterior to the caudal fin base (presumably through or near the hypural plate). The fork length in 95 per cent of those tagged was 16 inches or less and was

TABLE 5. FREQUENCY DISTRIBUTION OF LATERAL LINE SCALE COUNTS IN STRIPED BASS FROM ALBEMARLE SOUND, NORTH CAROLINA, AND THE EDISTO AND SANTEE RIVERS, SOUTH CAROLINA. THE LAST COLUMN (%) INDICATES THE PERCENTAGE OF SPECIMENS WITH 60 OR FEWER LATERAL LINE SCALES.

Locality	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	No.	Mean	%
Albemarle Sound, N. C.	....	....	....	....	....	....	....	....	1	9	7	2	1	4	2	26	62.5	3.9
Edisto and Santee R., S. C.	2	1	....	2	1	....	2	....	2	....	....	....	....	....	....	10	56.1	100

TABLE 6. FORK LENGTH OF STRIPED BASS WHEN ORIGINALLY TAGGED FROM 1948-52 IN THE AREA FROM MASSACHUSETTS TO CHESAPEAKE BAY

Length in inches	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Number	2	6	27	95	88	73	77	86	91	80	51	14	9	2	2	1	3	2	1

usually 9 to 15 inches. The frequency distribution of the length of those tagged is shown in Table 6; two additional specimens not listed were 29 inches long and one was 32 pounds.

Some 792 (8.5 per cent of those tagged) were returned, of which 764 had usable data. Of these 92 per cent were recovered within a year. Tags were usually returned within 5 to 9 months and only a few were out more than 20 months (see Table 7). The best rate of return came early in the program (1950-51) when there may have been less bitterness between groups utilizing the resource.

While this type of tagging program has produced results of value, it is recommended that it not be tried again. Since the general migratory habits of striped bass along the Atlantic Coast are fairly well known, future tagging programs should be designed with a definite purpose in mind. They should be carried on by fishing research agencies, rewards (probably at least $1) should be offered for returns, and an intensive follow-up should be made in each area to insure the maximum possible recovery. The purpose of the program should be explained to those engaged in the fishery where captures are expected. The nature of the fishery and opportunity for recovery of tags in the regions concerned should be carefully considered in interpreting results. The studies of Calhoun, Fry and Hughes (1951) and Calhoun (1953) indicate great need for further experimentation with materials used for tags and pins.

Western Long Island Sound. The tagging results are significant mostly in relation to the stock fished in the western quarter of Long Island Sound during spring, summer, and fall. Fin ray counts of specimens of the 1949 year class obtained from Cos Cob, Connecticut, indicate this stock to be largely of the Hudson race. Several thousand bass were tagged in this area and 555 were recovered; of these 372 (67 per cent) were retaken in the Hudson River, mostly in the spring fishery; 156 (28 per cent) were recaptured in the western quarter of Long Island Sound (seldom east of Fairfield, Connecticut, or Northport, Long Island) and only 27 (5 per cent) were recaptured from elsewhere (see Table 8 and Figure 1). Of the latter, five were retaken off Connecticut and Rhode Island from the mouth of the Connecticut River and eastward; eight were caught on the eastern and southeastern end of Long Island; six were taken in New Jersey at Great Bay (2), Toms River (1), Maurice River (1), Barnegat Bay (1) and Mullica River (1); and four were taken in both Delaware Bay and Chesapeake Bay.

More tags were recovered of those attached in 1950 than for any other single year. Of those tagged at Greenwich, Connecticut, and

TABLE 7. DISTRIBUTION OF TIME LAPSE BETWEEN TAGGING AND RECOVERY OF STRIPED BASS TAGGED FROM 1948-52 IN THE AREA MASSACHUSETTS TO CHESAPEAKE BAY

No. of months	1–	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of recoveries	27	29	36	36	33	63	77	75	85	45	33	24	13	8	8
No. of months	15	16	17	18	19	21	22	23	24	26					
No. of recoveries	5	6	1	1	1	2	1	1	3	1					

TABLE 8. SUMMARY OF 555 RECAPTURED STRIPED BASS ORIGINALLY TAGGED IN THE WESTERN QUARTER OF LONG ISLAND SOUND

Locality and year tagged	Number recaptured			
	Total	Hudson River	W. quarter L.I. Sound	Other localities
W. end Long Island Sound N. Shore, New York, 1950-52	14	10	2	2 Saybrook, Conn., & Montauk, L. I.
Greenwich, Conn., 1950	234	180	43	11 Sag Harbor & Gardiners Bay, L. I., Providence, R. I., Toms R. & Great Bay, N. J., Delaware Bay (3); Chesapeake Bay (3)
Greenwich, Conn., 1951	146	99	45	2 Thames R., Conn., & Great Bay, N. J.
Greenwich, Conn., 1952	45	18	26	1 Montauk, L. I.
Stamford to Fairfield, Conn., 1948-52				5 Conn. R., Conn.; Bridgehampton, L. I.; Maurice R., N. J.
South Shore—Whiteside to Northport, L. I., 1948-52	76 40	53 12	18 22	Delaware Bay; James R., Va. 6 Niantic R., Conn.; East Hampton & Moriches Bay, L. I.; Barnegat Bay & Mullica R., N. J.; Chincoteague Inlet, Va.
Totals (percentage)	555	372 (67%)	156 (28.1%)	27 (4.9%)

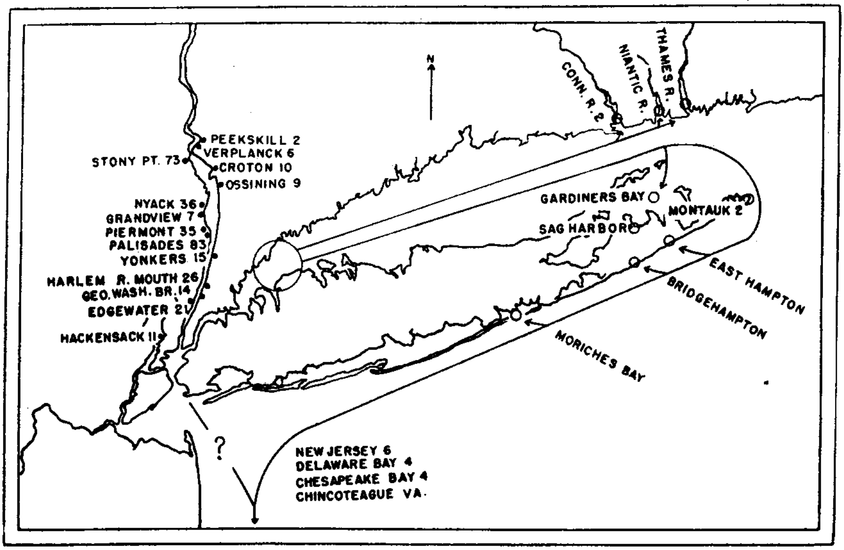

Figure 1. Map of Long Island, New York and the Hudson River showing the localities at which 555 tagged striped bass were recovered. They were originally tagged in the western end of Long Island Sound (marked by large circle on map), mostly in the vicinity of Greenwich, Connecticut (see Table 8). Those recaptured from the Hudson River for which specific locality data were not available are not indicated. The number of recaptures at an indicated locality is one unless otherwise noted after the place name.

nearby localities such as Cos Cob, 234 were recovered. For those for which precise date of tagging is available the data are as follows: May (8), June (14), July (53), August (59), September (58) and October (16). Of the 234 recovered 76.3 per cent were taken in the Hudson River drainage. Most of these (164 bass) were captured in the Hudson River during the spring fishery in April and May. Eight per cent were recaptured at Greenwich or Cos Cob within several miles of the place where they were tagged, the same summer or fall (8 spcimens), the following summer and winter (9 specimens) or the summer of 1952 (2 specimens). By-month recoveries were May (4), June (2), July (6), August (1), September (3), October (2) and January (1). An additional 7.2 per cent were captured in the western quarter of Long Island Sound in nearby areas. These were captured in April (1), June (1), July (4), August (7), September (3), and October (1), and except for one recaptured in 1952 were about evenly divided between 1950 and 1951. This seems to connote a summer population which does not move far from the western quarter of Long Island Sound. These presumably are joined from time to time and in varying, but usually small numbers, of Chesapeake stock which find their way westward in the Sound rather than following the usual migratory path northward to Massachusetts. This assumption is based on the results of tagging in 1950 which show that only 3 per cent migrated as far as Delaware and Chesapeake Bays and only 1.6 per cent were recovered as far away as eastern Long Island and New Jersey.

The 146 returns from those tagged at Greenwich and Cos Cob, Connecticut, in 1951 gave a similar picture but with fewer returns from the south; the Hudson River produced 68 per cent, mostly during the spring following tagging. From the locality of tagging (Greenwich) 18 per cent were recaptured and 12 per cent retaken in nearby areas in the western quarter of Long Island Sound. Only 2 per cent were taken as far as western Connecticut and New Jersey.

Six bass 9 to 10 inches long tagged at Greenwich, Connecticut, on August 25 and September 6-10, 1952, were recaptured nearby below the Cos Cob, Connecticut, power dam on January 20, 1953. Fishermen with a thorough knowledge of local conditions report that for the past 20 years bass have been taken from time to time in the winter at the power plant "flume."

Bass tagged at other localities in the western quarter of Long Island Sound also show the same general pattern of movement, the vast majority being captured in the Hudson River or at areas close to the point where tagged.

Hudson River and New York bays. At The Narrows which separate Lower from Upper New York Bay numerous bass were tagged, mostly from September 9 to November 18 in 1950 and 1951; 92 were recovered. During the following two spring seasons and in the fall of 1952, 89 (96.7 per cent of those recovered) were recaptured in the Hudson River and its tributary, the Hackensack River. As may be noted in Table 9, most recoveries were made in the spring; 43 in 1951 and 31 in 1952 compared with fall recaptures of 12 in 1951 and none in 1952. All recoveries were made during the first spring or in the fall one year after they were tagged which apparently is due to a lack of permanency of the tags rather than an indication of the natural mortality of the stock. Virtually all tags were returned from the fishermen engaged in the spring shad fishing, without whose fine cooperation little data would have accumulated. However, it is known that many tags were recovered and not made available. The sparsity of returns from sport anglers seems to indicate a paucity of the latter rather than any shortage of striped bass.

One striped bass tagged in April, 1952, was recovered later that spring in the Hudson River at Edgewater, New Jersey. Two others tagged at the Narrows on July 5 and 6, 1952, were recaptured between Palisades and Hastings-on-Hudson in the spring of 1953. Three speci-

TABLE 9. LOCALITIES IN THE HUDSON RIVER DRAINAGE OF RECAPTURES OF 86 STRIPED BASS ORIGINALLY TAGGED DURING THE PERIOD FROM SEPTEMBER 9 TO NOVEMBER 18, 1950 AND 1951 AT THE NARROWS, BETWEEN UPPER AND LOWER NEW YORK BAYS, NEW YORK CITY. RECAPTURES IN 1951 WERE ORIGINALLY TAGGED IN THE FALL OF 1950 EXCEPT THOSE INDICATED IN ITALICS IN THE SECOND COLUMN BELOW, WHICH WERE TAGGED IN THE FALL OF 1951. ALL THOSE RECAPTURED IN THE SPRING OF 1952 WERE ORIGINALLY TAGGED IN THE FALL OF 1951.

	Year Recovered			
	1951		1952	
	Spring	Fall	Spring	
Locality of recapture	April-May	Sept.-Dec.	Mar.-June	Total
Hudson River				
Locality not specified	1	....	....	1
Stony Point	19	1 + *7*	....	27
Ossining	1	....	....	1
Nyack	1	1 + *3*	....	5
Grandview	1	....	....	1
Piermont	1	....	11	12
Palisades	4	....	10	14
Yonkers	1	....	2	3
Harlem River mouth	5	....	....	5
George Washington bridge	1	....	....	1
Edgewater, N. J.	8	....	5	13
Hackensack River	....	....	3	3
Totals	43	2 + *10*	31	86

mens (3.3 per cent of those recovered were taken elsewhere and were recaptured in New Jersey within 50 miles of The Narrows where they were tagged. One tagged October 29, 1950, was recaptured in the river at Highlands, New Jersey, near the Highland River bridge on April 3, 1951; another marked November 10, 1951, was taken on February 6, 1952, in Shark River, New Jersey; the third was tagged November 18, 1950, and was taken in the Toms River area during the week of February 10, 1952.

The same type of upstream movement of striped bass was noted from 34 recaptures in the Hudson River originally tagged in 1948 (6 specimens), 1950 (12 specimens), and 1951 (16 specimens) in Upper New York Bay. Five of these were first tagged during the period July 3 to August 22 and the remainder were marked from September 17 to November 17. All 34 recaptures were from the Hudson and 29 were made in the spring during the period March to June; five were taken in the period September to December. With five recoveries no more precise data on locality of recapture are available than Hudson River. The other 29 recoveries were as follows: Peekskill (1), Stony Point (5), Ossining (1), Nyack (7), Piermont (6), between Palisades and Hastings-on-Hudson (5), mouth of Harlem River (1), and Edgewater (3). Five recoveries were made during the same fall in which they were originally tagged which gives further evidence of a movement upstream into the Hudson River, perhaps for overwintering purposes.

Another series of striped bass was originally tagged at Gravesend Bay and Hoffman Island (Lower New York Bay). Five were recaptured in the Hudson River during October and November, 1951. One marked at Hoffman Island on October 14 was retaken at Stony Point on November 11, 1951. Single specimens were recovered in May to June from Hyde Park, Verplanck, Alpine, and Hackensack River.

A summary of 133 recoveries of striped bass originally tagged in Lower New York Bay, the Narrows and Upper New York Bay shown in Figure 2 reveals that all but three (2.3 per cent) were retaken in the Hudson River upstream from the point of tagging. Only two (recaptured at Toms River and Shark River, New Jersey) actually moved any considerable distance outside the area since the third was recaptured at Highland, New Jersey, which is located at the southernmost point of Lower New York Bay.

It is inferred from the above data that there is a large movement up the Hudson River either in the fall of the year or early in the spring. When viewed in the light of our knowledge of the existence of an upstream Hudson River race, this movement seems to be, at least in part, a spawning migration. It also appears that the Hudson River race and a relatively small proportion of the Chesapeake race also winter in the Hudson River. The possibility seems remote that any considerable number which pass downstream through the Narrows go any considerable distance either north or south.

Twelve were recaptured in the Hudson River which originally were tagged in the Hudson in the stretch from 96th Street, New York City, to the Albany-Troy dam. None tagged in the Hudson were recaptured outside the Hudson. The only known upstream migrant was tagged at Englewood, New Jersey, on May 4, 1952, and was recaptured at Piermont, New York, in late May. Three moved downstream; one tagged at the Albany-Troy dam June 2, 1951, was retaken at Stony Point October 29, 1951; a second tagged at Stony Point on September 16, 1951, was recaptured at Upper Nyack, New York, in late October 1951; and a third marked off Haverstraw in September 1951 was taken in October at Upper Nyack. Six striped bass originally tagged off Stony Point in 1951 were recaptured at or close to the area of release. For these, the dates of tagging followed by the date of recovery (in parentheses) are July 26 (August 20), September 16 (October 29), September 30 (October 29), October 3 (October 7), September 19 (September 30, and September 19 (November 11). There is an indication here of a wintering population near Stony Point. This was a well known fact to commercial fishermen who formerly fished the area near Stony Point and Haverstraw in the fall.

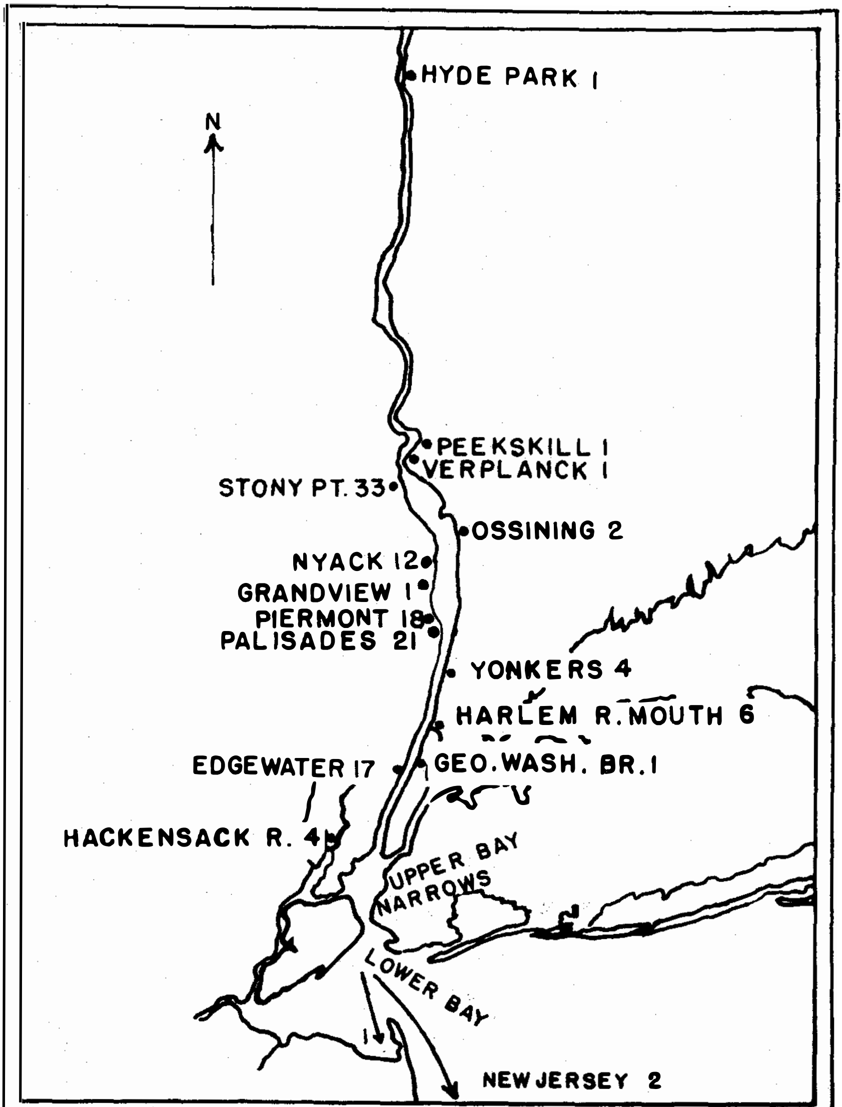

Figure 2. Map of the Hudson River, New York showing the locality of recovery of striped bass tagged in the Upper New York Bay (34 specimens), The Narrows (92) and the Lower New York Bay (5). Most were tagged during September to November 1950 and 1951 and the majority were recaptured the following spring.

Southwestern Long Island. Data on the recaptures of 32 striped bass originally tagged in 1949, '50 and '51 along the southwest shore of Long Island from Coney Island to Jones Beach are available. Tags were originally affixed from April 3 to November 20; two-thirds were tagged in the fall after September 1. Six (18.8 per cent) were taken in April, June and November, in the same area where they were tagged. Sixteen (50 per cent) were taken in the Hudson River from Verplanck to Yonkers. Of these, 3 were taken in August and Sepber and the remainder in the spring from March to May. A single specimen tagged at Jones Beach, April 18, 1951, had moved to Port Jefferson on the north shore of Long Island by July 9, 1951. Another, tagged on July 21, 1951, in Swift Creek, Freeport, was one of an overwintering group taken at the Cos Cob, Connecticut, power dam on January 20, 1953. One tagged at Far Rockaway May 6, 1951, was recaptured on July 20, 1951, in Great South Bay, Long Island.

Only 6 specimens or 19.3 per cent of all recaptures were recovered any considerable distance from the release area. One tagged at Jones Beach, April 28, 1951, was found at Westport, Massachusetts, on June 12, 1951. Two tagged on September 30, 1949, and October 22, 1950, were retaken at New Jersey at Avon-by-the-Sea on November 24, 1949, and at Shark River on July 20, 1951. Two tagged on November 1, 1950, and July 10, 1951, were recaptured in Delaware at Indian River Inlet on December 6, 1951, and near Makon on January 10, 1951. Another tagged on August 28, 1950, was retaken on March 1, 1951, at Swan Point, Chesapeake Bay.

Although these data on migration are relatively few it is in line with our findings regarding the existence of two races which seasonally mingle in the Coney Island to Jones Beach area. Some are apparently of the Hudson River stock and relatively fewer are of the Chesapeake-Delaware type, the migratory path of which was worked out by Merriman (1941).

New Jersey. Of the bass originally tagged in the fall (September 17 to November 30, 1950, '51 and '53) along the northeast New Jersey coast from Sandy Hook to Manasquan, 15 were subsequently recovered to the southward either in known overwintering areas such as Toms River, Barnegat Bay or Great Bay or had moved southward to Delaware Bay (3 specimens) or Chesapeake Bay (4 specimens). Six bass 14 to 16 inches long of a group originally tagged in northeast New Jersey (Asbury Park, 5 specimens, and mouth of Shark River, 1 specimen) during the period October 26-November 25, 1948 and 1950, were recaptured the following spring in the Hudson River from the area between Nyack and Piermont, New York. These may have overwintered in the Hudson River or have been part of a breeding migration.

Four were also tagged and recovered in summer (July 11-August 12, 1951) along the northeast coast of New Jersey. Those tagged at Deal (1 specimen) and Bradley Beach were recovered later that summer or early fall (August 6 to September 15, 1951) at nearby Asbury Park, Elberon, and Shark River. Another specimen tagged at Barnegat Jetty in late August, 1950, was recaptured at a short distance to the northward, Bay Head Canal, October 19, 1950. The inference from the small sample is that a proportion of New Jersey stripers remain in the same or a nearby area through the summer.

Delaware Bay. Ten returns are available from striped bass 9 to 12 inches long tagged originally in Delaware Bay, at Salem Cove, Salem, New Jersey. Six tagged from September 6 through November 1, 1950, 1951 and 1952 were recovered from Delaware Bay during the period January 14 to March 18. The captures occurred the winter or early spring following the release in each case. The returns were from Delaware Bay off the region between Little Creek and Bowers, Delaware, and were probably taken in the short winter fishery which has long been known in Delaware Bay. Three returns originally tagged at Salem were from the Chesapeake Bay. One tagged at Salem Cove June 4, 1951, was recaptured on October 14, 1951, in upper Elk River, which is near the western end of the Chesapeake and Delaware Canal. Another return from Millers Island in upper Chesapeake Bay recaptured on April 1, 1952 (originally tagged Salem Cove, October 27, 1951) also might have used the Canal. The third return first tagged at Salem Cove September 17, 1951, was recaptured in Chesapeake Bay off Matapeake on February 10, 1952.

Chesapeake Bay. Twenty recoveries in Chesapeake Bay and tributaries of stripers mostly 8 to 10 inches long marked in the spring (3), summer (3) and fall (14), 1949, were all made from within Chesapeake Bay or one of its tributaries and none marked in Chesapeake Bay were recovered from outside the Bay.

Massachusetts. Five recoveries of bass originally tagged in Massachusetts (September 18 to October 13) were all made south of the area and although the data are sparse, confirm the previous findings of Merriman (1941). Recoveries were made in Delaware Bay (January 25); Toms River, New Jersey (February 10); East Hampton (November 2) and Patchogue (November 12), Long Island; and one tag was recovered from the fish market, Stamford, Connecticut.

Two other Massachusetts returns are available. One 21-inch specimen tagged at Plum Island River, Newburyport, Massachusetts, on

May 23, 1952, was retaken in the Merrimac River on June 16, 1952. Another 14-inch specimen, tagged on May 6, 1951, at Wareham, Massachusetts, was retaken on March 30, 1952, at Salt Pond, Rhode Island.

CONCLUSIONS AND SUMMARY

The presence of one race, such as the Hudson race, located in the center of the migratory range of another race such as the Chesapeake, with a segment of the latter regularly migrating north to Rhode Island, Massachusetts, and perhaps farther, requires explanation. A study of tag returns indicates that in the late spring the Hudson race, or a portion thereof, regularly moves to the western end of Long Island Sound. This Hudson stock seldom goes eastward beyond Fairport, Connecticut, or Northport, Long Island. Some also migrate out of the mouth of the Hudson River but do not often go father east along the south shore of Long Island than Jones Beach. In the fall there is a reverse movement into the Hudson River where the striped bass is found in numbers as far upstream as Stony Point. Actually it is this latter or upstream migration which is proven beyond doubt by tag returns.

Merriman (1937 arnd 1941) showed that striped bass of the Chesapeake race apparently migrate independently and strike off the New Jersey shore, the south and southeast shore of Long Island where concentrations are known at points such as Montauk. From there they move almost directly north to such well-known bass areas as Niantic River, Point Judith, Rhode Island, and northward. During the fall southern migration, it seems that a relatively few individuals of the Chesapeake race get into the western end of Long Island Sound and a few enter the mouth of the Hudson River. Most make their way southward to the New Jersey coast and the Delaware and Chesapeake Bays.

In the present study the returns from bass tagged in Massachusetts generally confirm the findings of Merriman (1941) of a southward coastwise migration in the fall.

Racial studies using fin ray counts confirm previous findings of an upstream race which is found in the Hudson at Haverstraw and northward. The lower Hudson, south of Haverstraw, has a population of young which at least in some years are derived from Chesapeake stock or bass with similar characters. It seems improbable that the upstream stocks in the Hudson River are a result of modification due to different external physical conditions. On the basis of the character index (Table 4) the Hudson race is separated 70 per cent from the Chesapeake race. The dorsal count gives the best separation of any single character; the count is 11 more often than 12 in the Hudson race and the reverse in the Chesapeake race.

A sample of 35 striped bass, ten to twelve inches long, taken on May 11, 1953, at Point Saconnet, Rhode Island, had a mean of 56.5 for character index and had other counts which indicate without reasonable doubt that these fishes were not of upper Hudson River origin, but were probably of Chesapeake or Delaware stock.

Evidence is presented of a possible endemic stock in Nova Scotia which is close in some counts to southern populations in Albemarle Sound and the Edisto and Santee rivers, South Carolina. The Albemarle Sound population seems to be endemic or nearly so although it is closely related to Chesapeake stock. The South Carolina stock is virtually 100 per cent separable from the Albemarle Sound stock on fin ray and low lateral line scale counts. There is additional evidence of subraces within Chesapeake Bay and there is a hint that upstream populations may differ in having lower counts.

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DISCUSSION

DISCUSSION LEADER WALLACE: Have you made any attempt to analyze stocks of fish after they have grown sufficiently to start to move, in an effort to detect the origin of the stocks in any given spot, using these basic data that you have collected?

DR. RANEY: Yes, we have, Dave.

For example, a week ago I visited with Jim Watson down at Rutgers, and we arranged a "task force" and went down in southern New Jersey and obtained 57 large striped bass, from 1½ to 6½ pounds. We made tests on these fish, and they lined up with the Chesapeake Bay stock. In other words, the frequency distribution was identical with the frequency distribution we had previously while working on young fish of known origin from Chesapeake Bay. We can say with confidence that this stock of fish—from the Mullica River, New Jersey—were of Chesapeake Bay stock, and we now know that they have moved out of there and found that they have undoubtedly moved farther north.

This is well known, that a stock of fish produced in one area like Chesapeake Bay will contribute to a fishery which may operate many miles distant, such as Montauk Point, Massachusetts, and even off of Maine.

DR. LLOYD L. SMITH, JR. (Associate Professor, Institute of Agriculture, University of Minnesota, St. Paul, Minnesota): Have you any data on the relative abundance of these various stocks, and if so, do they vary simultaneously?

DR. RANEY: Actually, no adequate sampling method is available to measure the size of these stocks.

In general, along the Atlantic Coast, the Chesapeake Bay area produces most of the striped bass. I can say that without fear of contradiction. The Hudson River stock is important mostly as a local fish in the western quarter of Long Island Sound, and here it is of great importance because there are many people who fish out of New York City. They don't all fish for striped bass, but a great many do. So we do know that these local stocks, like the Hudson stock, are of great importance, especially for the sport fisher.

In this striped bass program we are trying to set up sampling methods along the coast so that we will get some indication of the strength of the various year classes in the same summer the year class is produced.

At the moment the method is to wait until the year class comes into the fishery, at an age of 2 years, when the fish are about 10 inches long, or an age of 3 or 4 years, when they are 16 to 18 inches long. Then, by working back, if we have a good catch, we can say that, well, the 1942 year class was a good one, or the 1951 year class was. We are trying to bring that up to date, to make better predictions, if possible.

DR. WILLIAM SHELDON (Massachusetts Cooperative Unit, Amherst, Mass.): Ed, in your introductory remarks you made some comment about the populations of striped bass, to the effect that you thought they were in better shape than in '34. Would you care to elaborate on that?

DR. RANEY: I think most of you remember that back in 1934, in Chesapeake Bay, the striped bass fishing was lousy. In 1936 a perfectly tremendous number of bass came into the catch. My figures aren't fresh in my mind, but where one had been caught in 1934, in 1936 they caught thousands, so that was a tremendous year class. The 1936 year class was the one which actually started the striped bass on the comeback trail.

We have had a succession of good year classes, not every year, of course, but 1940 was fairly good, and 1942, and certainly in recent years the year classes have been good. I know from experience that this last summer there was a terrific catch of young in the Patuxent, the Rappahannock, the James and the York Rivers, in Chesapeake Bay, in the Hudson River and in Albemarle Sound. I should say that my studies were done in September, when these young were about 3 inchs long, so I can say with fair confidnce that two years from now the fishing is going to be pretty good in Chesapeake Bay, off One O'Clock Point, off places in New Jersey and off Massachusetts, because the 1953 year class was a good one.

However, we still don't have adequate sampling methods for making precise predictions, and that is one of the things I hope the various states involved in this program will work out.

Incidentally, the states that now have research programs, or will, shortly, are Massachusetts, Connecticut, New York, New Jersey, Maryland, South Carolina and —believe it or not—Florida. There is an endemic population of striped bass in St. Johns, Florida, which is important to the sport fisherman.

CONSERVING NEW ENGLAND HADDOCK

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The international mesh regulation for haddock fishing on Georges Bank went into effect June 1, 1953. The purpose of this paper is to report on the effects of this regulation during the first seven months of its operation. Conversion from small- to large-mesh gear took place gradually. A few boats converted soon after June 1, but conversion was not complete until October 1. From June 1 eight large trawlers were licensed to fish with small mesh in order to provide information necessary for testing the effect of the regulation. Observers were sent to sea on both large-mesh and small-mesh boats to sample the catches and to sample the fish discarded as well as those landed.

Until this regulation became effective, trawlers caught and discarded at sea millions of pounds of small haddock with nets having cod end meshes averaging 2⅞ inches (Herrington, 1935; Graham, 1952a, 1953b; Premetz, 1953). The regulation requires a minimum mesh size of 4½ inches inside dimension.

The purpose of this minimum mesh regulation is to increase the age of first capture of haddock, that is, to save the undersize fish for later capture at a larger size. An advantage is gained by saving young fish only if they grow sufficiently fast and if enough of them survive to be caught at a later date. Growth rates and total mortality rates are well known for Georges Bank haddock (Graham, 1952b). We calculated, using Beverton's (1952) formula, that with known growth and mortality rates and with present fishing effort, the optimum sustained yield would be obtained if the effort were applied to ages down to but not below three. Since there is a market for fish somewhat smaller than three-year-olds, fish of ages down to two and one-half years or slightly younger were regularly landed.

Accordingly the size of mesh in the cod end of nets was adjusted to allow escapement of fish two and one-half years of age and younger (Graham, 1952b). The lowest age of capture with the small-mesh cod ends had been one and one-half years. Again using Beverton's formula we calculated that increasing the lowest age of capture from one and one-half years to two and one-half years would increase the annual landings of haddock about 30 per cent after a new equilibrium had been attained if fishing effort remained the same. With the lowest age of capture the effort could be considerably increased without re-

[1]Director, Woods Hole Laboratory.

ducting the total yield. In fact, greater total yields would be expected with fishing intensity increased up to 25 per cent.

The immediate effect of the regulation was expected to be a slight decrease in landings due to a loss of a few small marketable fish. This decrease was expected to be less than 10 per cent the first year and to be compensated by benefits the second year. Thereafter there were to be increasing benefits until a maximum was attained several years later.

The results of the first few months of regulation have been more gratifying than expected. The small fish have been saved but the expected initial decrease in landings has not occurred. Instead there has been a definite benefit enjoyed by the large-mesh boats beginning from the time of conversion.

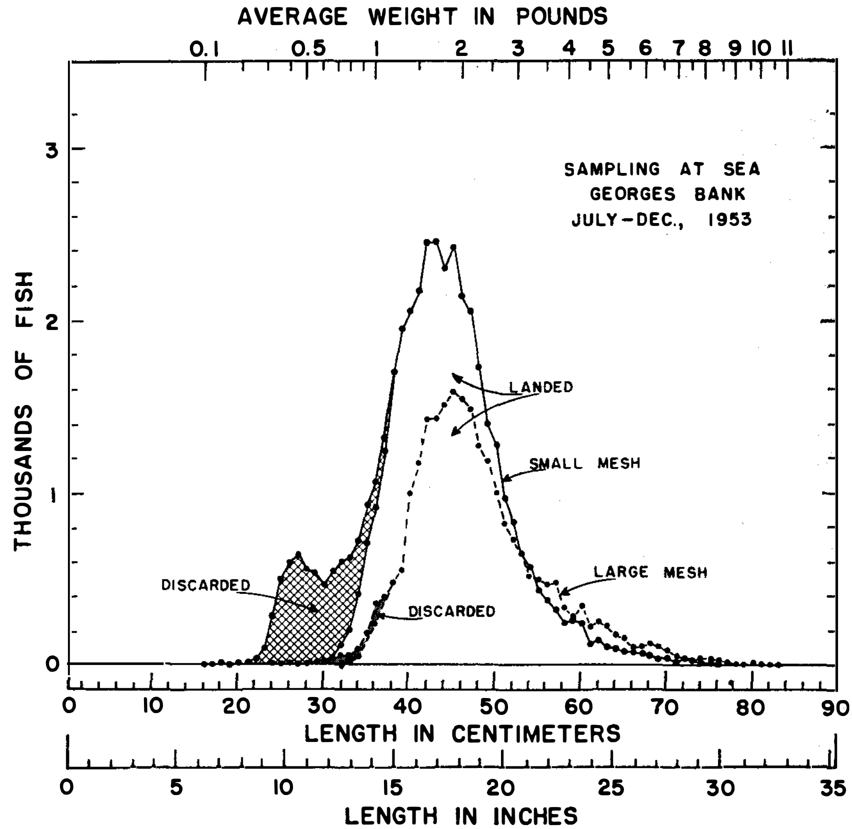
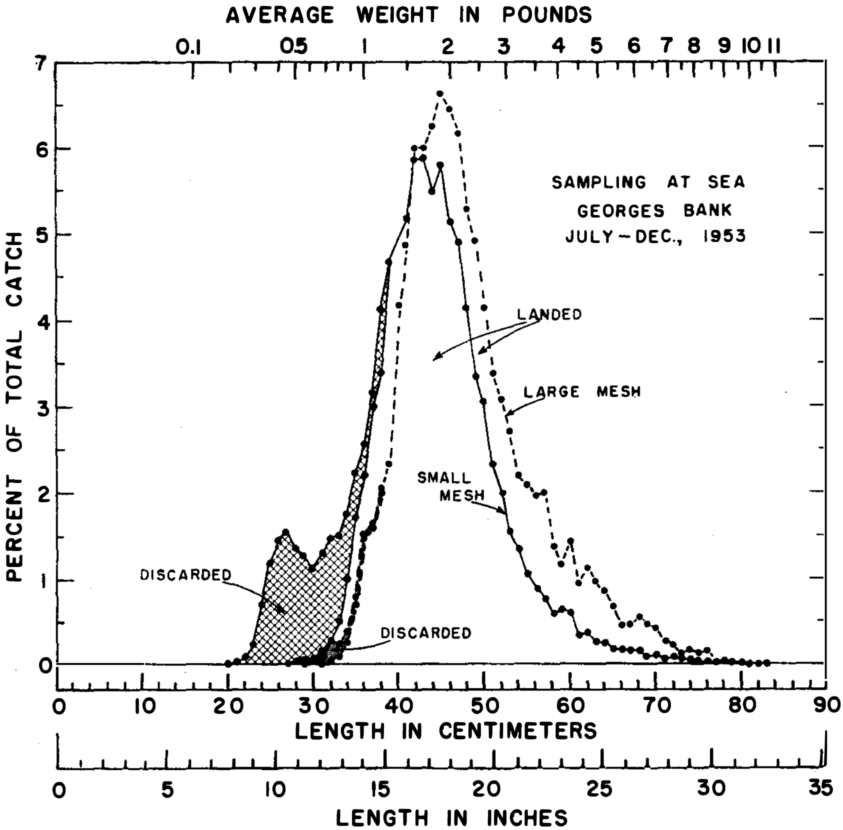


Figure 1. Size composition of Haddock catches on 14 observed trips during first seven months of regulations, June to Dec. 1953. Vertcal Scale: Thousands of Fish.



Figur 2. Size Composition of Haddock on 14 observed trips during first seven months of regulation, June to Dec. 1953. Vertical scale percent of total catch.

Figures 1 and 2 present a comparison of size distribution of fish caught by licensed small mesh vessels with that of fish caught by the large mesh vessel. It will be noted first that the quantity of discarded fish was reduced to a negligible amount by the use of the large mesh. Over two million haddock were saved by the use of these nets during the first half-year of the regulation and its use was not general for more than three months of that period. Another point demonstrated by these data is the lower landings of marketable fish under 40 cm. in length (2.5 pounds) by large mesh vessels. This loss, however, was more than compensated for by greater numbers of large fish caught and landed. Since these larger fish weigh more per individual, the net result was a benefit to the large-mesh boats.

The magnitude of this benefit is shown in Table 1. It will be noted that the average landings of haddock by the large-mesh boats during the last three months of 1953 were about 2,000 pounds per trip greater than that of the small-mesh boats. Other species of fish, such as cod and pollack, were also taken in greater quantity by the large-mesh boats. The total of all species landed by large-mesh boats was about 8,000 pounds greater per trip.

This direct comparison of landings of small-mesh boats and large-mesh boats for the same period is not a fair one because no account is taken of different sizes and efficiencies of the vessels represented. A more valid test is a comparison of each group's landings in the three months of 1953 with their respective landings in the same period in 1952. This comparison is also shown in Table 1. It will be noted that in the 1952 period the average catch per trip of haddock by the main part of the fleet, those boats which were subjected to regulation in 1953 (Group B), was less than the average catch per trip of the eight boats which in the 1953 period were licensed to continue fishing with the small mesh (Group A). Their total catch of all species, however, was slightly greater than that of the selected eight boats. Apparently the particular eight boats later selected for licensing normally tended to fish in areas in which haddock are proportionately more available than other groundfish.

In 1953, during the period of complete conversion of all regulated vessels, the catch of haddock from Georges Bank was down for all boats but to a greater degree for the licensed study boats. The total catch of all species held steady for the large-mesh vessels but went down 10 per cent for the licensed boats.

The landings of groundfish at Boston alone during the three month period amounted to about 33 million pounds, worth about three million dollars as landed. Had the regulation not been in effect, this

TABLE 1. COMPARISON OF LANDINGS OF SMALL MESH AND LARGE MESH VESSELS FROM GEORGES BANK

A. Average catch per trip[1] for period October, November, December, 1953

Group	Haddock Pounds	All Fish Pounds
Group A (8 Small Mesh Boats)	47,700	67,300
Group B (32 Large Mesh Boats)	49,600	75,500

B. Comparison of landings during October, November, December, 1952 with same period in 1953.

Group	Landings of Haddock Pounds per trip 1952	1953	% change	Landings of All Fish Pounds per trip 1952	1953	% change
Group A (8 boats)	60,900	47,700	– 21.7	75,200	67,300	– 10.5
Group B (32 boats)	54,800	49,600	– 9.5	75,400	75,500	+ 0.1

[1]The number of days fished per trip is fairly standard as the length of trip is subject to union regulation.

amount would have been about ten per cent less, or down by about $300,000, There is every indication that the advantage enjoyed by the large-mesh vessels will continue throughout the year, when the benefit will be at the rate of $1,000,000 annually.[2]

What is the reason for these better landings? It was suggested when the regulation was proposed (Graham, 1952b, p. 30) that the new nets might prove more efficient and thus reduce any deleterious initial effect caused by the loss of some small marketable fish. Experiments by Davis (1934) in England had indicated greater catches of the larger sizes of haddock with a three-inch mesh than with a two and one-half inch mesh.

When the advantage of the larger mesh in the Boston fleet was first noted, it was suggested that perhaps the fishermen had changed their fishing practices. Colton (unpublished manuscript) has found that there is to some extent a separation of sizes of haddock with depth on Georges Bank. At certain seasons of the year, at least, larger haddock are found in depths greater than 90 fathoms, and the actual pounds of haddock available per tow are greater there than in depths less than 60 fathoms.

If fishermen should tend to fish deeper in order to avoid concentrations of small fish because of a loss of some of the smaller sizes, they would obtain larger catches by dragging in the areas of larger fish. However, our present analysis of the distribution of fishing effort with depth does not reveal any difference in the habits of the large- and small-mesh boats. The study boats during the last three months of 1953 spent as much of their time proportionately in depths over 90 fathoms as did the large-mesh boats. We are forced to conclude for the present, at least, that the comparatively greater landings of the large-mesh boats is due to greater efficiency of the large-mesh nets.

The effect of the conservation of the young fish will, of course, not be evident for a year or two. This advantage will be added to that resulting from the more efficient net. The increased catch of the larger fish will not negate the value of conserving the small fish. Increasing the efficiency of the net constitutes an increase in the fishing effort, and, as stated above, increasing the effort up to 25 per cent will result in increased total sustained yield.

Thus the large-mesh net seems to be operating with a double advantage: small fish are being saved to add to the catch later at the same time that catches of larger fish are being immediately increased.

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[2]This is assuming that the net has the same beneficial effect on Nova Scotian banks as has been calculated for Georges Bank. A large proportion of the effort of the Boston fleet is now spent on Nova Scotian banks.

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DISCUSSION

DISCUSSION LEADER WALLACE: The question of mesh size and what it will do has always been an important issue, and I think he has demonstrated how valuable it can be when the change in mesh size is based upon a series of careful research studies.

MR. CHARLES E. JACKSON (National Fisheries Institute, Inc., Washington, D. C.): I want to ask Dr. Graham if the fishing time is the same with the regulated as compared with the non-regulated mesh. In other words, was there any more time put in trawling with the large mesh than the small mesh, in your figures?

DR. GRAHAM: The figures I showed gave pounds landed per trip, and a trip is rather a standard length of time. The length of the trip is regulated by the union regulations—about 8 days—so we consider that as a very good measure.

We heard some reports that the skippers were reducing the revolutions of the engines when they were using the large mesh. We thought perhaps that offered less resistance, and the captains wanted to trawl at the old speed, but we don't have enough information on that to make any statements. The boats may be traveling a little faster.

The large mesh saves some time for the fisherman because he doesn't have to cull. What he doesn't want has already gone through the net. With the small mesh they had to spend a lot of time culling out the small fish. That does not increase the number of tows, because with fishing the way it is now, they always get the deck cleaned up before the next tow comes in, anyway.

It simply means the fishermen have more time to relax and play cards or whatever they do. The number of tows per trip is the same.

MR. WALLACE: Dr. Graham, I believe you computed that, theoretically, it would take same period of time before there would be an increase in the catch by the 4¼" gears. How do you account for the fact that in the first six months there was this very pronounced improvement in the fishing with the 4½" gears, even though the fish had not had a chance to grow?

DR. GRAHAM: That is due entirely to the increased catch of large fish, which are caught both by the large and the small mesh, and will be added to the effect of the conservation of the small fish. We can't expect to get the benefit from the conservation of the small fish for a few years.

As I said before, this was not completely unexpected. Davis, in England, in 1934, conducted some experiments on different sized meshes, and found the larger mesh to be more efficient in trawlers, catching more pounds of fish per tow than a small-mesh net. It is hard to visualize. You think the net doesn't offer very much resistance to the water, but moving pictures under water show that there is a terrific strain on the meshes of the net when they are open.

Of course, we are quite gratified by these results, even though we didn't predict this large change, because it was quite a battle getting this regulation through. I have been in it only three years. The battle started years ago, and it was going thick and heavy when I entered the picture.

First of all, the fishermen said it wouldn't do any good to use the large mesh because the mesh would fold together anyway, and that you couldn't conserve that way. We finally got them convinced that it would do some good, using British underwater films, among other things. Then when the regulation became a definite thing, and they realized they were going to have to use the large mesh, they said: "We can't possibly make a living fishing with a large mesh like that." When they actually saw the large size they would have to use, they were aghast. They said, "This won't hold any fish at all. They'll all get through."

After the regulation was put into effect, they made very strong representations to cancel the whole thing. There were many times when we thought the project would soon collapse, but it is in effect now, is being enforced and the fishermen like it.

At present they are not quite sure whether to believe us or not. They don't accept figures like this just because somebody presents them to them in black and white. Right now I think they are in a transition period where they are beginning to realize they are better off with the large mesh, so it may be difficult to get volunteers to use the small to prove our point conclusively.

Right now we are not having any trouble, and I think everyone is happy as far as conservation is concerned. There are economic problems connected with this fishing that I am not going to discuss today.

DR. SMITH: My experience with commercial fishermen is that anything that makes it easier is all right with them. Now, when they had this big mesh—a few of them, a few years previously—why didn't these fishermen notice the same results which they have now noticed as a result of regulation, since it is easier to handle them on deck and so on? Why didn't they stay with it?

DR. GRAHAM: In the first place, it's not easy to see this effect. Fishermen don't keep records too well, and you have to compare this year's catch with last year's. If the regulation goes into effect when there is a strong year class passing out of the picture, and the abundance is dropping and they try something experimentally that way, they will blame it on the net, just as during the summer and early fall, everything was blamed on the large mesh, so you can hardly expect the fishermen to realize that they are better off with the large mesh.

As a matter of fact, they were using too light a twine, so they were getting tear-ups. If you break one mesh in the large mesh net, it leaves quite a hole; if you break one in the small mesh, it doesn't matter so much. I think that is probably one reason they kept using smaller meshes. We increased the weight of twine, using one almost lkie a piece of quarter-inch rope, made out of manila, very heavy and durable. It lasts just as long as the small mesh.

Another difficulty arose from the fact that you couldn't get complete cooperation in the industry. Fishermen are individualists. Perhaps one of them wouldn't go along with the idea, and one day he might bring in a larger catch, then the other would feel, "Well, this is getting us nowhere," and they would all go back to the small-mesh net.

CALIFORNIA'S TUNA AND YELLOWTAIL TAGGING PROGRAMS

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During the last several years, staff members of the Marine Fisheries Branch of the California Department of Fish and Game have conducted extensive marking experiments on various species of marine fishes, among them several of the tunas and one carangid, the yellowtail.

The department has pursued various phases of the tuna investigations for many years; the present tagging program started early in 1952. A few yellowtails were tagged as early as June, 1951, but full-scale tagging experiments did not become possible until 1952. In January of that year a major investigation of the yellowtail was undertaken with Federal Aid in Fish Restoration funds (Dingell-Johnson project California F-1-R).

The type of tag desired in both investigations was one which was (1) readily visible even when handling fish in bulk aboard a commercial vessel or in a cannery, (2) relatively permanent, (3) easily and quickly applied, and (4) not harmful to the fish. Plastic tubing tags have met these requirements and are used in both programs. Yellowtail are also being marked with plastic jaw tags which show great promise.

The tuna tagging program is concerned with three species: the yellowfin tuna (*Neothunnus macropterus*), the albacore (*Thunnus germo*)and the skipjack (*Katsuwonus pelamis*). A few California bluefin tuna (*Thunnus saliens*) have been tagged incidentally. The skipjack is not a "true" tuna in the systematic sense, belonging to family Katsuwonidae rather than Thunnidae. It can, however, be marketed as 'tuna" and comprises a significant portion of the catch.

Yellowfin and skipjack have pan-Pacific distributions, are essentially fishes of tropical and subtropical waters, and are the object of a single fishery in the eastern Pacific. California's commercial fleet ranges from Mexico to Peru; only a minute fraction of the catch orginates in California waters where these species are uncommon. Because of their relative rarity, they are seldom taken by California sportsmen. Albacore are found throughout the Pacific in more temperate waters. They are seasonal in their appearance off the western coast of North America, the California fishery usually reaching its peak in the summer. The fishing grounds extend north from central Baja California, Mexico, in some years as far as the Pacific northwest.

The albacore is not only the premium commercial tuna but is also an extremely important sport fish in southern California.

Two basic problems confront the tuna investigations. The first is whether the eastern Pacific fisheries are exploiting one or more relatively isolated subpopulations or whether there is an interchange to a greater or lesser degree of fish from the entire range. The second concerns age and rate of growth. No suitable means of aging any of these species has yet been devised. The purpose of the tagging program is to try to solve both of these problems.

Many nations are involved in or interested in the existing eastern and western Pacific tuna fisheries and in the potential central Pacific fishery. Obviously, no one state and no one country can hope to cover the entire area. California is particularly concerned because the tuna fishery is now the state's largest, both dollarwise and in terms of tonnage. However, many agencies are conducting tuna research, and the various programs conducted in the eastern and central Pacific are informally coordinated. Canada and the states of Oregon and Washington are working in the albacore studies. The U. S. Fish and Wildlife Service, through the Pacific Oceanic Fisheries Investigations based at Honolulu, and the Territory of Hawaii are studying all three species in the central Pacific. The Inter-American Tropical Tuna Commission, to which the United States and Costa Rica are currently signators, is concerned with the yellowfin-skipjack fishery. The Japanese have long been studying the tunas of their fishing grounds. As present, California's largest contribution is through the tagging experiments.

The yellowtail (*Seriola dorsalis*) is a coastal fish. It has been taken as far north as Monterey Bay in central California but it is rare north of Los Angeles county. Its range extends south to and into the Gulf of California, and offshore to include Guadalupe Island, Mexico. The center of its distribution lies in Baja California waters with only the northern fringe of the population extending into southern California.

The fish is utilized commercially but it is not one of the more desirable species. Its great value is as a game fish, for it is one of the most highly prized varieties taken by California anglers. Sportsmen pursue it, particularly out of San Diego, with much of the fishing effort expended at the Coronados Islands which lie just south of the International Boundary some 20 miles from San Diego. The season usually reaches a peak in late summer and fall off California and northern Baja California and few if any yellowtail are taken in winter and spring. Farther south catches are made year-round.

The objectives of the yellowtail study are essentially the same as those of the tuna program. There are the same problems of age and rate of growth and of migration. Judging from commercial records, central and southern Baja California is a center of abundance, and a fundamental problem is to determine whether the California sport fishery is drawing from that stock or whether it is dependent upon a smaller, localized group. Guadalupe Island is a good yellowtail area, and one of the first questions raised in the study was whether the fish there were insular or part of a coastwise population.

No reward is paid for the return of a tagged fish, but a wallet-size card giving the history of the fish is given to the captor. These cards were devised for the state's salmon tagging program and have met with extremely favorable response from both sport and commercial fishermen.

The several tagging programs now being conducted in southern California have received considerable publicity through newspapers, magazines, television and radio. Posters describing the programs and giving instructions for the return of marked fish are displayed wherever fishermen congregate. As a result, most fishermen are aware of the work and the great majority of those who catch a tagged fish are extremely cooperative.

Special posters for foreign distribution in the Japanese and Spanish languages are now being prepared for the tuna program.

THE TUNA TAGGING PROGRAM

Tags and techniques. Up to the time of the present experiments, no satisfactory means of marking tuna had been devised, despite many attempts. Early in the program, various staff members devised a number of tags, the most promising of which were subjected to field trials in 1952 and 1953. The development of the tags and the field trials have been reported upon by Wilson (1953). For various reasons noted by him, hook tags, Petersen disks, and bands around the caudal peduncle were rejected prior to the field trials. Opercular strap tags simliar to those used unuccessfully in California during the 1930's (Godsil 1938) were considered but were not used because of evidence of extensive shedding and because the tags were visible—and then not strikingly—on only one side of the fish.

The field trials were concerned largely with tags made of plastic tubing. These were affixed through the flesh of the back just posterior to the second dorsal fin. Five types were tested, two of which are currently in use. As now made, both are shorter than the originals described by Wilson but are otherwise identical. One, Wilson's type F, consists of an outside tubing about six inches long made of number

14XTE-30 Fibron. The legend is inscribed on a three-inch length of opaque white number 20XTE-30 Fibron. This is inserted in the larger tubing and a length of 27-pound braided nylon fishing line is passed through both. It is tied with a double square knot. The other, Wilson's type G, consists of an outside number 14 tubing 6 inches long through which runs a 16-inch length of opaque white number 20 tubing which bears the legend. This is tied in a double figure 8 knot and the ends trimmed. Legends are hand inscribed in black vinylite ink (California Ink Co., Los Angeles, formula 104N5A2) and read "Return Calif. Fish & Game San Pedro (number)."

Most of the men who have applied both tags prefer the type G because the knot can be tied much more rapidly. The nylon line of the type F tag is hard to cinch down on a wiggling fish, and the task of tying the relatively fine line is made doubly difficult by wet and slimy hands. Further, there is evidence, as yet inconclusive because of small numbers, that the type G tag is more readily observed than the type F. Of four tagged fish not seen at the time of capture and later found either in the hold of a vessel or in a cannery, three were marked with type F and one with type G. Roughly equal numbers of each type have been applied. In the type F tag there is a short length of opaque white plastic, the exterior tubing is translucent and the nylon line inconspicuous. The long piece of opaque white plastic in the type G tag is far more eye-catching when the two are seen side by side.

We have experimented with both colored and clear outside tubings. The colored tubings (blue, yellow and red) are sufficiently transparent to permit reading the legend on the inner tubing. Of the colors, blue has for no apparent reason given the best returns. At the present time we are using clear tubing almost exclusively, more because it was available than for any conviction as to its inherent superiority.

In applying the tag, one man holds the fish in a cradle while the second applies the tag, using a hollow stainless steel needle to pierce the flesh and carry the end of the tag through. Measurements are taken to the nearest one-half centimeter.

Releases. In 1952 and 1953, 11 major tagging trips were made, six on the department's research vessel *N. B. Scofield* and five on commercial tuna clippers. The tagging crew in the latter case consisted of two men, at least one of whom was a trained biologist. The area covered extended from central California to the coast of northern Peru (Figure 1). At the present time (March 1954) two tagging crews are at sea aboard commercial vessels and additional cruises will be scheduled as circumstances permit.

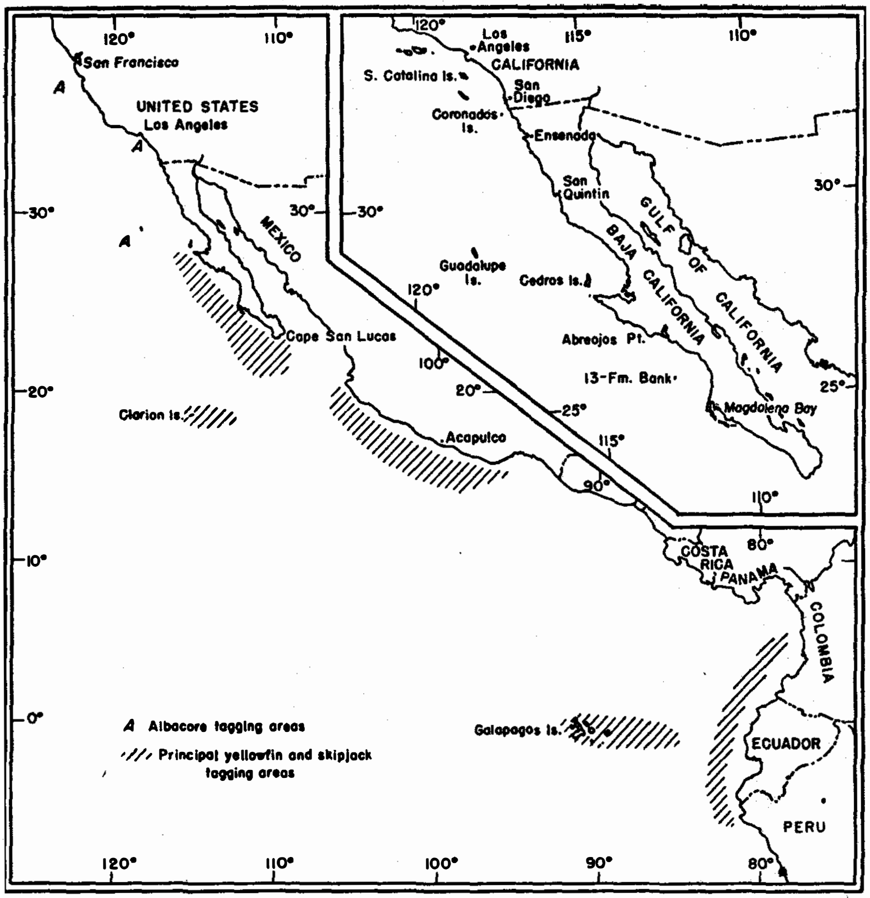

Figure 1. A portion of the eastern Pacific Ocean showing the area covered by the tuna investigations and (inset) further detail of the area involved in the yellowtail study.

The various segments of the tuna industry have been extremely cooperative with the program. We are particularly grateful to the captains and crews of the commercial vessels who have carried and are carrying our tagging teams. The fish for tagging are given to us, not a small item when yellowfin is bringing $350 per ton dockside. Carrying the tagging team means extra hands aboard—or fewer fishermen—with consequent dislocations of routine. In return, our men are expected to and do assist in the operation of the vessel as much as possible. At least one of our men was offered a part share in the proceeds of the cruise in appreciation of his help. Because of the distances involved and the vagaries of fishing, a commercial trip may last from a few weeks to several months. The longest in which our staff participated extended from October 25, 1952, to February 11, 1953. It was successful from our point of view with over 1,600 yellowfin and skipjack marked off northern South America and at the Galapagos Islands.

At the end of 1953, 3,135 yellowfin and 1,333 skipjack had been tagged, mostly off Mexico and northern South America. The northermost point of release is Guadalupe Island, where a few fish of both species were taken incidental to albacore work. The only bluefin marked were taken on this same albacore trip. The 1,335 albacore released in the two years were tagged off southern California in 1952 and central California and near Guadalupe Island in 1953. (See Table 1).

Recoveries. Tagged fish which have been returned to us have been in excellent condition. The marking wound apparently heals in a short time and the tags are readily noted. There have been 69 returns, and all but 4 of these were seen by the fishermen at or soon after the time of capture.

Recovery data are summarized in Table 1. All recoveries were made by commercial fishermen. The single bluefin recovery was surprising in that only three had been marked. This fish was both tagged and recaptured at Guadalupe Island. It had been at liberty five months.

All of the 20 skipjack recoveries came from the 1953 tagging off southern Baja California. The maximum time out was 42 days and the maximum movement 225 miles northward along the Baja California coast. While these returns came too soon to show any signifi-

TABLE 1. RELEASE AND RECOVERY DATA FOR TUNA TAGGED IN 1952 AND 1953 RECOVERIES ARE COMPLETE THROUGH FEBRUARY 1954. SEE FIGURE 1.

Date	Place of Release	Yellowfin Released	Yellowfin Recovered	Skipjack Released	Skipjack Recovered
Feb.-May 1952	Mexican mainland	345	4	1	0
Oct. 1952	Southern Baja California	278	9	106	0
Oct. 52-Feb.53	Northern South America, Galapagos Islands[1]	1139	3	499	0
Mar.-May 53	Mexican mainland	183	0	84	0
May.-Aug. 53	Southern Baja California; R.[2] Gigedo Islands	1181	17	643	20
	Totals	3135	33	1333	20

Date	Place of Release	Albacore Released	Albacore Recovered	Bluefin Released	Bluefin Recovered
Aug. 1952	Southern California	219	3	....	....
Aug. 1953	Guadalupe Island area	754	12	3	1
Oct. 1953	Central California	362	0	....	....
	Totals	1335	15	3	1

[1]Ten of the fish released off Central America; no recoveries.
[2]Three yellowfin and four skipjack released near Guadalupe Island; no recoveries.

cant migrations or growth, they did demonstrate that the fish were surviving the tagging operation. Skipjack are considerably more difficult to handle than the other tunas, and it had been feared that mortality caused by marking might be excessive. The lack of returns from the 1952 releases had furthered this concern.

There have been 33 returns from the 3,135 marked yellowfin tuna. Particularly interesting data on growth were obtained from three. Two of these fish were released off central Baja California in October, 1952 and recovered in May and June, 1953 off southern Baja California. The first, at liberty 205 days in which it moved about 290 miles, grew from 55 to 67½ centimeters, an increase of 12½ centimeters. The second, at liberty 260 days in which it moved about 270 miles, grew from 63 to 79 centimeters, an increase of 16 centimeters.

The third fish was released about 225 miles off the coast of Ecuador in December, 1952 and recaptured 350 miles south, off the north-central coast of Peru, in December, 1953, 372 days later. It had grown 33 centimeters in length, from 60 to 93. While this fish was not weighed, the average for a 60 centimeter specimen is about 9 pounds and that for a 93 centimeter individual is about 33 pounds. This indicates a weight increase in the order of 24 pounds for the year.

Making allowance for the diffierences in days at liberty, the first two fish were growing at a somewhat slower rate but one of the same general magnitude. Far more data are obviously required, but there is the suggestion from these recoveries that the growth rate is extremely rapid. If this proves true, it will be a factor of extreme importance in judging the condition of the fishery, which, it would then seem, would be dependent largely on young fish.

The Peruvian recovery was reassuring for another reason. Slightly over 1,100 yellowfin had been released off northern South America. There had been two returns almost immediately in the area of tagging, and then the group dropped from sight for the better part of a year. It was feared that there might have been deficiencies in tags or in technique; the third return makes the hypothesis that the fish moved south, out of the normal range of the California fleet, more attractive.

Most of the remaining recoveries were made near the place of and within a short time of release. The maximum movement was 525 miles. This fish was tagged near Acapulco, Mexico, and recaptured near Cape San Lucas, Baja California. Another fish moved from Clarion Island in the Rivilla Gigedo group to the coast of southern Baja California, a distance of 370 miles. Five others traveled from 200 to 350 miles in Mexican waters.

The most spectacular recovery to date is that of the now-famous albacore which was released off southern California in July, 1952 and was caught by a Japanese fisherman 550 miles southeast of Tokyo in June 1953 (Ganssle and Clemens, 1953). Two earlier recoveries from this same lot were made off Morro Bay, Central California, 200 miles northwest from that point of release, after four and six weeks respectively.

The 1953 albacore taggings have yielded 12 returns, all from fish released in the Guadalupe Island area. These fish showed a steady northward movement over a 45-day period and then disappeared. Needless to say, the staff will be following next summer's Japanese fishery with extreme interest. Of the 12 fish recaptured, two were taken 95 and 145 miles from the point of release after 24 and 23 day's liberty respectively. Nine others were taken at distances ranging from 27 to 39 days. The twelfth fish moved 680 miles in 45 days to a point about 50 miles off the California coast just north of San Francisco.

While it is too soon to have other than fragmentary information as to migratory habits and growth of any of the tunas, the results to date have been extremely encouraging. The tagging program is being pursued as rapidly as personnel and finances will permit. We hope before many years pass to have positive answers to some of the perplexing questions which face us.

THE YELLOWTAIL TAGGING PROGRAM

Experimental work. Experimental phases of the tagging program extended through 1953. Tests were conducted with many types of tags in an aquarium, in a water tunnel and at sea, where most of the fish released were double-tagged. The aquarium tests were made at the Scripps Institution of Oceanography, La Jolla, which provided space and cared for the fish from January until June, 1952. The water tunnel experiments were performed in March, 1952 at the University of Washington, Seattle, through the courtesy of Mr. D. L. Alverson and and Mr. H. H. Chenoweth. Tagging at sea was done from the department's research vessels, from a commercial purse seiner, from charter boats and from private yachts. We are particularly indebted to Mr. Ralph Larrabee, Newport Beach, who has several times taken staff members to Guadalupe Island, Mexico, on his yacht, *Goodwill,* to Mr. J. S. Sefton, San Diego, who carried two of our men from Guaymus, Mexico to San Diego on the Sefton Foundation research vessel, the *Orca,* and to Mr. Ben Fukuzaki, captain of the purse seiner *Stella Maris,* who volunteered to—and did—tag fish himself during his commercial trips.

Tags tested included Petersen disks, plastic plates stapled or riveted to the operculum, nickel opercular strap tags, cellulose nitrate opercular strap tags, plastic jaw tags, streamer tags, some of them hyrostatic, and the plastic tubing tags devised by the tuna staff.

Petersen disks were subjected to the greatest number of tests. These were the first tags used in the program and were selected as the base tag in double-tagging experiments at sea. The disks used were made of laminated cellulose nitrate and were one-half inch in diameter. They were applied in pairs one on each side of the fish under the insertion of the second dorsal fin. At first they were attached with stainless steel wire (type 302, 0.032 inches diameter), and later with monofilament nylon fishing line, mostly 18-pound test. In the aquarium (12 fish) and in the water tunnel (4 fish), the tags regardless of attachment took a position at right angles to the flow of water. At the conclusion of the experiments the wire-attached tags had either worked free through the flesh or were in the process of so doing. Of the three sets of nylon-attached disks in the aquarium, two remained in place for the duration of the experiment, 104 days, and the third came off in 66 days. The single pair tested in the water tunnel broke loose. (Maximum velocities in the tunnel were 25-29 miles per hour.)

Because of the apparent deficiencies of the wire attachment, few fish were marked at sea in this manner and none were double-tagged. All were released in early 1952. There were several recoveries during the 1952 season (late summer and fall), but none in 1953.

Extensive double-tagging experiments were conducted both in 1952 and 1953. In all, 2,327 fish were marked with nylon-attached disks in conjunction with one of the other tags. There were 91 of these fish recaptured, of which 65 had lost the Petersen disks. The use of Petersen disks has now been discontinued because of the far better showing made by other tags.

The several types of opercular tags were tested less extensively. They have the inherent disadvantage of being visible from only one side of the fish. Plastic tags stapled or riveted to the operculum worked through the bone; the three tested in the aquarium and two of the three in the water tunnel were shed. The third water tunnel tag was nearly free after 10 minutes at 20 to 29 miles per hour. In the double-tagging experiments 77 fish were marked with these tags and seven were recaptured, all in the season of release. One had lost the opercular tag. Use of these tags has been discontinued.

Opercular strap tags showed similar deficiencies and likewise have been abandoned. The nickel tags were remainders from the Pacific mackerel (*Pneumatophorus diego*) tagging program. They had proved useful on mackerel only for short-term studies because of extensive shedding (Fry and Roedel, 1949). Four yellowtail in the aquarium retained them only for from two and one-half to five months. Three tested in the water tunnel stayed in place.

The cellulose nitrate strap tags had a distinct advantage in size (3″ by ⅝″ *vs.* ¾″ by 5/32″) and, consequently, visibility, but apparently worked free rather rapidly. In the double-tagging experiments they were applied to 107 fish. Of these, four were recaptured but only one had retained the strap tag. These tags were not tested in the water tunnel. One was used in the aquarium and was still in place after one month, at which time it was necessary to dispose of the fish.

Streamer tags attached with nylon line below the middle of the second dorsal fin showed more promise than the others so far discussed. In fabricating these tags, the message was printed on waterproof paper. The paper was rolled around a length of braided nylon line and then dipped in liquid nylon to provide a coating. Four of these tags remained in place on aquarium fish for from one to three months. One withstood the water tunnel test. Of 196 double-tagged fish, 15 were recaptured of which 13 retained the streamer tag. There were, however, no second-season returns.

Hydrostatic streamer tags provided through the courtesy of Mr. Einar Lea of Norway were less successful. Six were tested in the aquarium, of which four were lost in from two to four months. One of five broke loose in the water tunnel. These tags were not used at sea.

The jaw tags are made of strips of cellulose 3 by ⅝ by 1/25 inches. All used so far have been hand-made. The strips are softened by immersing them in hot water and then molded into shape around a jig simulating the lower jaw. An overlapping flange permits their being snapped in place. To apply the tag a slit is made between the lower jaw and the tongue support through which the tag is inserted. The tagging operation is very fast and the mark can be seen from nearly any position.

One jaw tag was tested in the aquarium. It had been in place for two months at the conclusion of the aquarium experiments without apparent harm to the fish. None were tested in the water tunnel. Of 130 fish double-tagged at sea, the 15 recaptured all retained the jaw tag. Those examined were in excellent condition. The maximum time out was 86 days. Only 30 of these fish were relased in 1952, so the lack of second-season returns does not seem significant.

Because of the excellent results from these tests, limited though they are, jaw tags are being used in the 1954 program even though their long-term staying qualities and effect on the fish remain to be determined. Tags with printed legends laminated to protect the message from wear are being manufactured.

The second apparently successful type, use of which is being continued, is the tubing tag. The tuna tags described earlier and a modification of one of them has been used. The modification consists of substituting 40-pound test monofilament nylon for braided nylon in the type F tag. On yellowtail, these tags are attached below the middle of the second dorsal fin.

No tubing tags were tested in the aquarium. Two tested in the water tunnel remained in place.

At sea, 1,818 fish were marked with tubing tags and Petersen disks, all but 79 in 1953. There have been 55 recoveries with no losses of the tubes. The maximum time out is 81 days; like the jaw tags there has been scant chance of second-season returns. As with tunas, the tagging wound had healed perfectly in the recaptured fish seen by us.

The only fault found was that the ink faded on a few of the legends. The same ink applied to the same tubing held up perfectly in the great majority of cases, including all tuna returns. Where fading occurred, it affected only the portion of the legend outside of the fish; that passing through the body was unaffected. This suggested that light was a factor, and tests conducted by the ink manufacturer indicated that this was the case. It is believed that a minor modification of the formula will overcome this deficiency.

Releases. While a great amount of time has been spent in devising suitable tags for yellowtail, every opportunity has been seized to tag fish in large numbers to obtain data on the fundamental problems of migration and growth.

Releases are summarized in Table 2. The 16 fish marked in 1951 represent rather fortuitous catches made prior to the start of the formal program. In 1952, it did not prove possible to spend as much time at sea as had been anticipated, and on most of the few cruises that could be arranged, the worst kind of "fisherman's luck" prevailed. Actually, nearly 2,000 of the 2,553 fish tagged by the end of 1953 were taken on two cruises by departmental research vessels in August and September, 1953.

Almost all the fishing effort has been expended in central and southern Baja California and at Guadalupe Island.

A good start has been made in 1954. In January and February 594 fish were tagged in central and southern Baja California.

Recoveries. Of the 103 yellowtail recaptured (Table 2) only 8 had

TABLE 2. RELEASE AND RECOVERY DATA FOR TAGGED YELLOWTAIL. DATA ARE COMPLETE THROUGH FEBRUARY 1954. SEE FIGURE 1.

Date	Place of Release	Number Tagged	Number Recovered
June-Sept. 1951	Coronados Islands	4	1
	La Jolla, California	1	0
	Guadalupe Island	11	0
	Totals	16	1
1952	Coronados Islands	18	7
	Guadalupe Island	380	11
	Cedros Island-Abreojos Pt.	87	8
	Totals	485	26
1953	Coronados Islands	9	4
	Guadalupe Island	268	13
	Cedros Island-Abreojos Pt.	76	2
	Abreojos Pt.-Magdalena Bay	1,685	57
	Gulf of California	14	0
	Totals	2,052	76
Jan.-Feb. 1954	Baja California 25°44'N to 27°30'N	594	0
	Grand Totals	3,147	103

moved more than 25 miles. All recoveries occurred in the year of release. The maximum time out is 225 days; eight fish were at liberty more than 100 days. The lack of second-season returns and the small number of long-term returns is not too distressing. Only about 500 fish were marked in 1951 and 1952, most of them with tags later shown to be more or less unsatisfactory.

Further, the vast majority were released in August and September, 1953, and that there has been very little yellowtail fishing since November, 1953. As would be expected, no data on growth rates have yet been obtained.

Of the fish which moved appreciable distances, three traveled from Guadalupe Island to the mainland. Two were retaken near San Quintin, Baja California, slightly over 150 miles northeast of Guadalupe and about 150 miles south of the international boundary. These fish were released in June, 1952, and recaptured in November and December of that year. The third fish moved 240 miles southeast to the vicinity of Pt. Abreojos, Baja California, this in two months after its release in August, 1953.

The only recovery in California waters was of a fish released at the Coronados Islands in April, 1953, and recovered at Santa Catalina Island, 70 miles distant, in July, 1953. Another Coronados fish moved southeast to Ensenada, Baja California, 45 miles away.

The other three fish to move more than 25 miles traveled southeast along the Baja California coast. They were released in the Cedros Island area, two in 1952 and one in 1953. The first two were recaptured 90 miles distant after 86 and 213 days and the third 70 miles distant after only 11 days.

Some of the most interesting returns were of fish that did not move at all. On the successful trips of August and September, 1953, fishing was particularly good at a hitherto unnamed shoal in southern Baja California which we have christened "13-fathom Bank" (lat. 25°44'N, long. 113°10'W.). In August, 237 fish were released there, and in September, 1,168. During the September stay 24 of the fish marked in August were recaptured. Commercial fishermen worked the area in October and November, and took 40 fish released in September. One captain said that he caught "lots" of tagged fish, returning all but five to the water. The fish apparently left the bank in the next two months, for when staff members visited it in January and February, 1954, few fish were taken, and none had been tagged.

The yellowtail study, like the tuna, has far to go before the problems facing it can be solved. Again like the tuna, the results so far have been very promising, and given time, there is every hope of success.

SUMMARY

Successful means of tagging various species of tuna and the yellowtail (*Seriola dorsalis,* a carangid fish) have been developed since 1951 by the California Department of Fish and Game.

A tag made of flexible plastic tubing and affixed through the flesh of the back posterior to the second dorsal fin was devised by the tuna investigators. It has been modified several times and as now manufactured consists of a protective exterior translucent tube inside of which is an opaque white tube bearing the legend. There are two types. In one, the interior tube is longer than the exterior and is used for tying the loop closed. In the other, the interior tube is shorter than the exterior, and the tag is tied with a length of nylon line passed through both tubes.

The tubing tags have proved extremely satisfactory. They are relatively easy to apply, there is no evidence of shedding, the tagging wound (judging from recaptured fish) heals rapidly, and the tags are readily seen by fishermen.

In the yellowtail study (Dingell-Johnson project California F-1-R), a number of tags including the tubing tag were tested in the field, in an aquarium and in a water tunnel. The only type comparing favorably with the tubing tag in retention quality is a cellulose jaw tag which is affixed to the lower jaw through a slit made in the isthmus. There have been no known losses from either tubing or jaw tags. Extensive experiments with Petersen disks disclosed a very high shedding loss. Other tags tested included plastic tags stapled to the operculum, opercular strap tags of both metal and plastic, and two streamer tags.

All showed some shedding loss. Jaw tags and tubing tags will be used exclusively henceforth.

The work in both programs was to a large extent experimental in 1952 and 1953. With suitable tags, large-scale field operations are now in progress.

Releases and recoveries by species for all types of tags are: yellowfin tuna (*Neothunnus macropterus*), 3,135 released, 33 recovered; skipjack (*Katsuwonus pelamis*), 1,333 released, 20 recovered; albacore (*Thunnus germo*), 1,335 released, 15 recovered; bluefin tuna (*Thunnus saliens*), 3 released, 1 recovered; yellowtail, 3,147 released, 103 recovered.

The yellowfin and skipjack were released between northern Mexico and northern Peru, the albacore off California and Baja California, Mexico, and the bluefin and yellowtail off Baja California.

The most important recovery to date is that of an albacore tagged off southern California and recaptured off Japan. A yellowfin tuna in one year grew 33 centimeters and gained an estimated 24 pounds in weight. Other tuna recoveries showed movements of up to 665 miles over periods of up to 260 days. Only eight of the recaptured yellowtail moved over 25 miles. In both projects, much more information must be accumulated before the problems of migration and growth rate can be solved.

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DISCUSSION

DISCUSSION LEADER WALLACE: Has there been any work on the scales of tuna? I understand that on the East Coast the eastern bluefin can be identified to some degree of success up to the first five years or so.

DR. CALHOUN: I would like to put that question to our Chairman. I know nothing about them.

CHAIRMAN WESTMAN: Back in 1941 we were able to age eastern bluefins rather readily, up to about five years of age. Then the scale becomes rather difficult to read. I understand that at the University of Miami they have worked with the vertebrae with some success. Of course, when these tuna get up around five and six hundred pounds, it's just a kind of guess.

RESEARCH ON ANADROMOUS FISH PASSAGE AT DAMS

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The multitude of dams resulting from the development of our water resources for power, irrigation, navigation and flood control is seriously threatening the existence of our anadromous fisheries. If anadromous fish populations are to survive the adult fish returning from the sea must have access to spawning areas. Fingerlings, likewise, must be able to migrate safely to the sea. There are several serious aspects to the problem of fish versus dams, but the most immediate concern is that of providing safe passage at dams for both upstream and downstream migrants.

The Columbia River watershed provides one of the most spectacular examples of the fish passage problem. A series of large dams is planned in the main Columbia and in the Snake River, and lesser dams are proposed in most of the tributaries. Adult fish ascending to their present spawning areas may have to surmount as many as nine dams. Even small losses, injuries or delays at each dam could prevent spawning and result in decimation of the run. The small fish migrating downstream to the sea will also have to run this gauntlet of dams, and, because of the cumulative effects of such a series of hazards, relatively minor losses at each dam could jeopardize the entire fishery. If the fishery is to be protected, the passage of both adult fish and fingerlings must be achieved with the maximum efficiency.

The problem is urgent! There are already two major dams on the Columbia without fish passage facilities. These dams, Grand Coulee and Chief Joseph, cut off over 1,000 lineal miles of streams that were formerly available to salmon. This was not done through neglect, but because we were unable to provide an economically practical solution to the problem of fish passage at high dams. Plans and preparations are in progress for many other dams, and time, so badly needed for research, is growing shorter. The fate of the once-abundant runs of salmon and shad on the East Coast provides a grim reminder of the price of delay or failure in seeking the necessary answers.

Fishery agencies on the West Coast, well aware of the critical nature of the problem of fish passage, are expanding their research in an all-out effort to solve the problem while there is yet time. The personnel and facilities of colleges and universities are being enlisted in the search for ways and means of getting fish safely past dams. The U. S. Army Corps of Engineers, as a major dam building organization, is

[1]In the absence of Mr. Collins this paper was read by Dr. Herbert W. Graham.

providing funds for a broad program of "Fisheries-Engineering" research directed toward an economic solution of their fish passage problems in the Columbia River. In both the United States and Canada, fishery agencies are pooling information and coordinating research programs in an effort to insure that no promising possibility remains unexplored.

DOWNSTREAM MIGRANTS

A major part of the research effort will be directed toward that aspect of the fish passage problem which appears to be most difficult to solve—the protection of the downstream migrants. The migrating fingerlings move downstream following large water flows into diversions, turbine intakes and under spillway gates. Injuries and losses are often difficult even to measure and at this point of our knowledge, almost impossible to prevent. Mechanical screening has been used successfully at small installations but is impractical for the huge volumes of flow at large dams. There is need for an inexpensive method by which fingerlings can be directed away from dangerous areas into bypasses that will transport them safely below dams.

Experiments are being conducted both in the laboratory and in the field, examining the use of a wide variety of stimuli to direct the salmon fingerlings. These exploratory tests involve the use of electricity, lights, sound, odors, screens of air bubbles, dyes, louvers and other mechanical deflectors. At the moment, the most promising approaches appear to be in the use of electricity, lights and louvers.

The use of electric fish screens is not new, some installations having been in use for over 30 years. Most of such applications have endeavored to establish an electrical field as a barrier or "fence" to prevent the entrance of fish into a given area, the fish being repelled by the electrified area. These electric screens have generally proved to be unsatisfactory with migrating fish and particularly so with downstream migrants. The fingerlings seem unable to avoid the electrical field where they are stunned or even killed rather than diverted. In our present research, attention has been turned toward the use of the directional properties of electric fields. When fish are subjected to a field of pulsating direct current, the fish tend to move toward the anode. The experiments now in progress are attempting to take advantage of this electrotaxis in guiding fingerlings. Instead of attempting to repel the fish, the field is designed so that the fingerlings enter the field and are then oriented in the desired direction.

The use of electricity in guiding fingerlings is being approached cautiously, however, for while electricity can control the movements of fish, it can also injure or kill them. The voltage gradients necessary to affect the movements of small fish are frequently dangerous for large fish. This creates a complicated problem, for at some locations there are times when fingerlings of several sizes and species are present as well as large adult upstream migrants. A solution to this situation is being sought in electrical fields with progressively increasing zones of voltage gradients that will affect larger fish first, directing them out of the area before they can enter the voltage zones necessary to direct the small fish. As experiments proceed investigating the wave forms, pulse frequencies, pulse durations, voltage gradients, current densities, and field patterns most effective in directing fingerling movements, parallel experiments explore the ranges of these same characteristics that may be injurious to the fish or that might modify normal reactions temporarily in such a way as to affect their survival. Long-range experiments are also in progress to test the possibility that exposure of fingerlings to an electrical field might affect their future reproductive ability.

The application of the principle of electrotaxis to the problem of protecting downstream migrants has much promise, and it is being investigated on a large scale by several research agencies. However, the method will require a detailed knowledge of the relation between the electrical energy levels producing electrotaxis and those with detrimental effects on the fish.

The use of phototaxis in directing fingerling movements is also not new. Experiments in which lights have been used in various ways to either attract or repel fingerlings have met with varying degrees of success but never with enough to justify their general application to the problem of fish protection. However, laboratory and field tests now in progress once again are calling attention to the extreme sensitivity of young salmon to light. It is hoped that with an increased knowledge of the nature of this phototactic reaction a more successful application can be made. Current research interest centers upon the use of a barrier of light, sharply defined on the upstream side, located diagonally across the direction of stream flow to deflect the fingerlings, taking advantage of their reluctance to pass into an area of higher light intensity.

There are serious obstacles to be overcome in developing a satisfactory technique utilizing light as the guiding stimulus. One of these is the problem of making such a method function satisfactorily in the daytime. Although our present information seems to indicate that the largest part of fingerling downstream migration is at night, a technique that was ineffective in daylight hours could only be looked upon as a partial solution. The avoidance of the light deflector at night might result only in the delay of the normal downstream movement of a large part of the fingerlings until daylight. The excessive turbidity of many of the streams concerned may also make application of a light technique very difficult. The great advantage of a method of guiding fingerlings with light, and a strong incentive to expend every effort to develop such a technique, is that the method would not involve the danger of injury to the fish that is ever present in electrical and mechanical methods and the method would have the further advantage of a minimum of interference with water flow.

A third technique showing promise as a means of collecting migrating fingerlings from a large volume of water is the use of louvers. The louver screen consists of a series of vertical baffles or louvers placed diagonally across the stream flow with a bypass located on the extreme downstream end. Fingerlings seem reluctant to pass through the narrow openings between the louvers and are thereby deflected into the bypass. Experiments with the use of a louver screen now being conducted at a large water diversion at Tracy, California, indicate that this type of screen is equally effective by day or night, and the experiments show very little evidence of any injury to the fish. The chief disadvantage of this technique appears to be in a large structure of louvers required, which, from the standpoint of initial cost, maintenance and interference with flow, probably limits its usefulness at major dams.

While all of the methods for guiding fingerling so far explored seem to have limitations, it must be borne in mind that most of this research is still at a preliminary stage. If a general solution to the problem of directing fish that will be applicable to all situations and circumstances, all sizes and species of fish is not found, the problem of fingerling passage might still be solved satisfactorily by applying a variety of techniques, each adapted for a particular set of conditions. It is of the greatest importance, therefore, to examine carefully every potential method for its possible use even in restricted circumstances, not only alone, but in combination with other methods.

UPSTREAM MIGRANTS

By comparison to the problems involved in providing safe passage for downstream migrants, the task of passage facilities for upstream migrants seems relatively easy. Yet, we have little reason to feel complacent about our knowledge relating to passage of adult fish. There is evidence that our present fishways are oversize, inefficient and far too expensive. The reduction of fishway costs is becoming increasingly important to the protection of the fishery resource. The cost of construction and maintenance of fishways has now reached such proportions that many people concerned with river development policy are beginning to ask if the value of the fishery warrants such expenditures. For example, the estimated construction cost of fishways at six new dams planned on the Columbia River is in excess of $100,000,000, with the maintenance and operation costs estimated to be more than $1,000,000 annually. Precedents have already been established on the Columbia River for dams without any facilities for fish passage. An important part of the research on adult fish passage will be concerned, therefore, with finding more economical methods for providing adult passage.

The high cost of fish passage facilities can in many cases be traced directly to a lack of definite knowledge on fish behavior and of the principles involved in fish passage. This lack of information is reflected in fishways designed with huge safety factors in size and auxiliary flows, and, in the expensive provision made for duplication of facilities (*i.e.*, both fish-ladders and fish locks at major dams.)

To provide a means of acquiring the information a special type of laboratory is being planned in which it will be possible to measure the reactions of the migrating fish under controlled experimental conditions. The structure will be located on a bypass into which fish can be diverted from one of the major fishways at Bonneville Dam. The fish will swim into the laboratory where they can then be subjected to a variety of experimental conditions without interfering with the normal passage of fish in the main fishway. When the fish have passed through the experimental area and their reactions are recorded, they will swim out of the laboratory and reenter the fishway. Experiments are planned investigating the swimming abilities of the fish, their reactions to light, form, water turbulence and spatial relationships. An effort will be made to discover the factors controlling their rate of movement through fishways and the size of fishway required for given numbers. By the use of choice techniques the preferences of the fish for various flow properties, water temperatures and chemical conditions will be measured. The behavior of fish in tunnels and conduits, open channels and pools will be examined using the actual full scale dimensions and flows used in fishways at major dams. The construction of this unique type of laboratory will make possible an entirely new experimental approach to the problem of fish passage.

PRINCIPLES OF FISH PASSAGE

As intensive efforts to solve fish passage problems get under way, one point becomes increasingly clear—that, although our concern is for the application, little progress will be made until we have an understanding of the basic principles involved. What are the principles involved in providing passage for fish? The answer will only be found in the behavior of fish. Whether the problem is—How to attract adults into fishway entrances without delay? How to collect fingerlings to prevent them from entering dangerous areas? How to design bypasses? or, How to disperse fingerlings at bypass exits to reduce predation?—all of these require an intimate knowledge of the factors influencing the direction and rate of fish movement. The biological term for this aspect of fish behavior is fish orientation. It includes all of those reactions that determine the position and movement of the fish in relation to its sourroundings. Principles of fish orientation are the basic principles involved in providing passage for fish. A systematic search for the principles of fish orientation may provide the shortest and surest route to a solution of the problem of fish passage at dams.

NEW JERSEY'S SALT WATER SPORT FISHERY INVENTORY, 1953

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Aware of the heavy fishing pressure, both recreational and commercial, upon the coastal waters, the New Jersey Division of Fish and Game, in January of 1952, inaugurated an inventory of her sport fishery. It was anticipated that such a survey would yield the following information:

1. The number of anglers utilizing this resource.
2. The number of man-days fished by each phase of the fishery, bank, surf, party boats, charter boats, rowboats and U-drives.
3. The major species taken by each type of angling.
4. The need, if any, to manage the fishery on a state level, and how it could be accomplished.
5. To obtain any major trends in the fishery from year to year.

As this work was without precedent in New Jersey, and since some six hundred miles of coastline were involved, not to mention the thousands of acres of bays and estuaries, the chief problems to be dealt with were: (1) the location of facilities available to the angler; and (2) the design of a sampling technique that would permit, in any subsequent year, reproduction of data which could be compared with the utmost confidence. The first year of work was devoted towards this end.

The preliminary task was locating the various facilities. They were catalogued as follows:[1]

Facility	*Number operating*
Rowboats	5,081
U-drives	252
Party boats	277
Charter boats	319
Bank	
Surf	

Not included in the above are the thousands of private craft utilized by fishermen and out-of-state boats that fish the same grounds.

Since the main problem was sampling anglers who were fishing all types of gear in six facilities located along miles of beaches, jetties and banks, thousands of acres of ocean and bays, its scope is clearly recognized, and the problems involved were many. In the first place, the inventory was viewed with mixed emotions by all of the vested interests. In most cases, unfounded suspicions by certain groups, or disinterest by all anglers as a whole, resulted in poor cooperation. Therefore, it was soon realized that the many questionnaires that had been designed were useless and any information would have to be obtained through personal interviews.

Because of the limited personnel available, the 1953 sampling procedure was handicapped by certain physical limitations, *i.e.,*—(1) only two activities could be sampled during one day's sampling by each of the two crews; and (2) because of the distances involved these activities could only be sampled within certain defined areas—(See below).

The sampling effort on each facility was based on the 1952 data, as follows:

Party and charter	58%
Rowboats and U-drives	29%
Bank and surf	13%

[1]Party boats: Boats that take out groups of anglers at a fixed price per person, or head, and are open to all anglers. Bait is furnished, and rods may be rented. The fee is usually $4.00. These boats may fish either a half day or all day, and can carry from 20 to 125 anglers, depending upon their size.

Charter boats: Boats (including skipper) that are hired for a day's fishing. The average charter party is six persons. The total fee is from $50 to $75. Bait, lures and tackle are furnished.

Rowboats: Essentially what the name implies. They usually carry two or three anglers and the fee is generally $2.50 with an additional charge of $5.00 for the rental of an outboard motor. Some liveries have a towing service, which costs $1.00 per round trip. All bait and gas is extra.

U-drives: Generally, boats of skiff type fall into this category. The fee is from $25 to $30 for a day's fishing, or so much an hour.

Bank fishing: Construed to be fishing from any beach or construction situated on any bay or river.

Surf fishing: Fishing from any jetty, beach or construction on the ocean front.

(As grouped thusly, each pair of facilities can be sampled simultaneously

Many anglers have definite ideas as to when fishing is best; so, in order to insure adequate coverage, two shifts were inaugurated so that each fishery could be checked sometime during its activity:

Shift #1—5 A.M. to 1 P.M.
Shift #2—1 P.M. to 9 P.M.

"Flight days" were designated for each month. On such days, an aerial survey, covering the entire state, was made, to count the number of vessels in the fishery, as well as the number of bank and surf anglers.[2]

The coast was divided into two sections of three areas each. The size of any area was based upon what could be covered during a given sampling period. Specific sampling locations were defined on the following basis: Such a location would have no less than twenty rowboats, or four party or charter boats. However, when checking bank and surf fishermen, the entire area was sampled.

Each month was treated independently. Week-end days were separated from week days. All shifts, flights, days-off, areas to be sampled and sampling locations were randomized.[2] If, for any reason, data could not be obtained in the assigned location, the observer proceeded to the location where that particular activity could be sampled. When checking bank and surf anglers, postcards were handed out to obtain statistics on total catch and hours fished. Twelve per cent of these cards were returned to the laboratory.

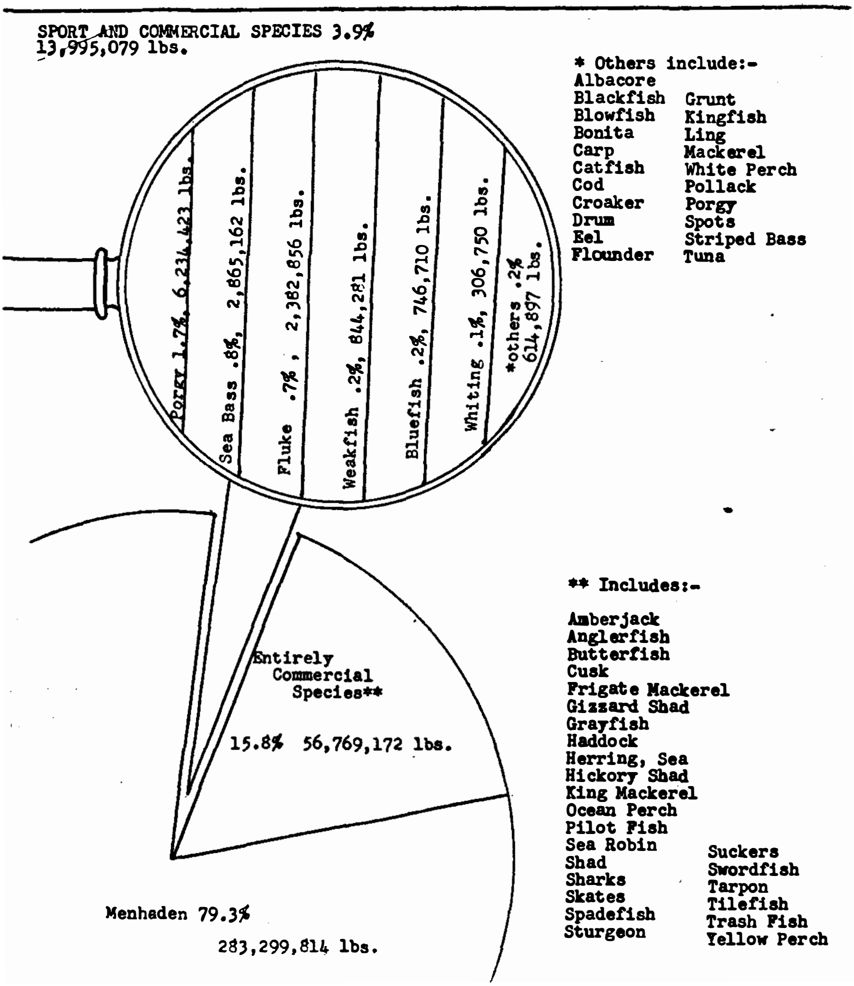
When considering the scope of such a project, and the mass of data obtained, it is readily understandable that the problems of processing and collecting such data uniformly are an important consideration. This was simplified by designing a Keysort Card System.

Out-of-state craft were to be determined by subtracting the total count of vessels seen during flights from inlet activity records made available by the Coast Guard. As the compilation of data progressed it was noticed that Coast Guard records were not available for two of the busiest inlets, and also that no indication was made as to what portion of the inlet activity consisted of commercial vessels.

It is anticipated that the Coast Guard will cooperate during the coming season by distinguishing between these craft where inlet logs are maintained. As for Sandy Hook and Cold Spring Harbor Inlets, project personnel will make total counts of outgoing vessels, to coincide with certain flight days. On other randomized flight dates,

[2]This represents a modification of the technique of stratified random sampling.

Fig. 1. Species Composition of Commercial Catch—May-September



project personnel will be stationed at various bank and surf fishing centers to measure the turnover. This information, used in cooperation with the flight data, will indicate what percentage of the angling population can be observed at any given time.

Private craft represent the most elusive aspect of the census of our sport fishery. It was anticipated that interviews and postcard censuses would furnish the needed information, but due to scattered locations, irregular hours of operation and lack of time, little data were obtained. This year, time has been made available for sampling this phase of the fishery.

TABLE 1. MAY-SEPTEMBER, 1953

Commercial Catch					Sportsmen's Catch	
Value	Pounds	Per cent of poundage	Species	Per cent of poundage	Pounds	Value
$398,043.00	2,803,125	70.5	Sea Bass	29.5	1,170,230	$116,172.00
410,719.00	2,333,636	49.2	Fluke	50.8	2,400,244	422,422.00
341,787.00	6,103,356	76.5	Porgy	23.5	1,874,127	104,951.00
237,851.00	731,850	38.6	Bluefish	61.4	1,159,412	376,808.00
184,122.00	814,701	66.1	Weakfish	33.9	416,358	94,096.00
7.705.00	124,276	64.1	Blackfish	35.3	69,564	4,347.00
15,603.00	69,042	33.1	Bonita	66.9	139,129	31,443.00
6,312.00	24,276	64.1	Chub-Mackerel	35.9	69,564	3,478.00
1,062.00	2,761[1]	17.8	Striped Bass	82.2	12,364	4,760.00
$1,603,216.00	13,131,878				7,310,992	$1,158,477.00

[1]Sold by "sportsmen."

Two part-time assistants were hired for the summer months to work with project personnel. This reduced traveling time and permitted more energy to be devoted to field work.

The data for 1953 have, in part, been analyzed, and it is felt that our present sampling technique does provide us with the desired information.

To illustrate, a comparison between the catches of commercial and sport fishing may prove of interest. (Fig. 1, Table 1.) The period for the comparison is May through September, when the sport fishery is at its peak. During this period, the commercial harvest consisted of some 385,000,000 pounds, of which 79 per cent, or 283,000,000 pounds were menhaden. Fifteen per cent, or 57,000,000 pounds were strictly commercial species, such as amberjack, butterfish, shark, skates, etc. Of the additional four per cent (14,000,000 pounds) 11.9 million pounds consisted of sea bass, fluke, porgy and bluefish.

The sportsman, during this period, had a total production of 7,000,000 pounds, of which 6.5 million pounds consisted of sea bass, fluke, porgy and bluefish.

The total production for each of these three species is as follows:

Species[3]	*Commercial*	*Sportsman*
Sea bass	70%	30%
Fluke[4]	49%	51%
Porgy	76%	24%
Bluefish	39%	61%

[3]The figures represented can only be an approximation of numbers of fish captured, and relative abundance.

[4]It must be emphasized that during this period, fluke are an estuarine species and not heavily fished until the fall and winter when they return to deeper waters.

TABLE 2. COMPARISON OF FISH/MAN FOR PARTY AND CHARTER BOATS[1]

1952			1953	
Number of men	Fish/man	Species	Number of men	Fish/man
452	9.37	Bluefish	416	8.85
912	8.42	Fluke	2,870	5.84
775	19.45	Mackerel	......	......
1,626	22.95	Porgie	1,585	18.17
878	16.75	Sea Bass	1,370	12.26
386	12.23	Weakfish	154	14.57
5,029			6,395	

[1]Based upon catches of 66⅔ per cent of a given species.

Similar comparisons may be made within the sport fishery, differences in species composition between each facility, as shown in Tables 1 and 2.

The authors wish to express their sincere thanks to Mr. Earl Atwood and Dr. Albert Swartz, of the Fish and Wildlife Service, for their many constructive suggestions and criticisms.

TABLE 3. PER CENT OF TOTAL CATCH FOR EACH FACILITY—1953

Species	Party boat	Charter boat	Rowboat and U-drives	Bank	Surf
Bluefish		33.47	1.40	11.20	16.24
Fluke	21.46	30.30	42.10	34.36	14.62
Porgy	33.31	17.56	2.30		
Weakfish	4.86	2.70	36.14	5.38	35.68
Kingfish			1.54	2.78	11.54
Sea Bass	33.47	2.32	2.34	15.89	1.26
Others	6.90	13.65	14.18	30.39	30.66
Total	100.00	100.00	100.00	100.00	100.00

DISCUSSION

MR. WALLACE: Thank you, Mr. Younger, for this interesting report. This is the first attempt that I know of to analyze the sport fishing picture in detail in any state along the Atlantic Coast, and I think the State of New Jersey is to be congratulated upon this attempt.

There are a number of questions which immediately come to mind. The first is: What is the most important type of sport fishing? We had a picture of what happens in the various groups, and I know that there is much discussion along the Atlantic Coast that surf fishing is the primary and most important type of recreational fishing. I wondered if your survey bore that out.

MR. YOUNGER: The 1952 data revealed that our sport fishing could be broken down as follows: 58 per cent of the people fished on charter boats, 29 per cent on rowboats, and 13 per cent on bank and surf. That seems small, but that's the way the figures were.

MR. WALLACE: In other words, the surf fishing, in the over-all picture, was a relatively minor part of the total recreational fishing in the state.

MR. YOUNGER: That seems to be the case. Of course, as you drive along the coast you will see thousands of people out on the beach, but they are not all fishing, as that one slide illustrated, with 126 people and only 46 actually fishing.

MR. CHARLES E. JACKSON (National Fisheries Institute, Inc., Washington, D. C.): I'd like to ask again about that striped bass division. Did I understand you to say that 83 per cent were taken by sportsmen, and the other 17 per cent was caught and sold by the sportsmen?

MR. YOUNGER: That's right. As I said, this was designed to pick up the major trends, and since our striped bass angling is more or less relegated to the minority, they failed to show up in our study. Of course, with more refined sampling, and so forth, you're naturally going into specific research.

MR. WALLACE: How do you account for the very great discrepancy between the striped bass in New Jersey and, for example, the fluke, which obviously is quite an important species?

MR. YOUNGER: The whole thing about the striped bass fishing is that we have a group who are more or less enthusiasts. Of course, as I said in my talk, our fishery is more than a summer fishery, and it is used by a great mass of people from the Philadelphia area along the shore. Actually, they are not too interested in one particular species. They are just going out to have a good day fishing.

MR. JACKSON: What is your minimum size length in New Jersey?

MR. YOUNGER: We have 18 inches along the Atlantic Coast; in the Delaware Bay area it is 12 inches, and anything over 20 pounds has to be returned to the water.

MR. JACKSON: Do you prohibit commercial taking of striped bass?

MR. YOUNGER: Along the Atlantic Coast and in our basin rivers it hasn't been prohibited, except in the Delaware Bay area, where, due to legislation between the states, it is.

MR. JACKSON: To what do you attribute the fact that commercial fishermen do not go after the striped bass?

MR. YOUNGER: That's not the point at all. The commercial man would very much like to go out after the striped bass. It's in the water and goes up and down the coast, so if you're going to have conservation of one specific species (this is strictly my own viewpoint), I can't see why you shouldn't have it for all, and have it up and down the whole coast.

But the way things are now, I mean the striped bass is one of those selfish things, again. It's strictly a sociological problem.

The sportsman went down when we had our netting season, and saw hundreds of stripers. Before, he was out there and fished a couple of weeks in the year and caught one fish. or sometimes no fish. He was quite shocked by the thing.

MR. JACKSON: So he became a commercial fisherman himself?

MR. YOUNGER: Yes.

MR. WALLACE: The situation in New Jersey is that nets are prohibited for catching striped bass, but you actually have this sportsman becoming commercial, to at least 17 per cent of the catch.

MR. YOUNGER: Well, I think we ought to clarify that a little more fully. That 17 per cent that was on the market during this period was more or less put on by the sportsmen hit by the fact that it was sort of a nice way to be compensated for his day's angling on the coast. He has money wrapped up in tackle. If he gets 10 cents a pound for stripers, he gets $2.30 for a 23-pound striper, which means he might get around to buying another plug.

MR. WALLACE: You wouldn't class that man as a sportsman, would you?

MR. YOUNGER: When does a man become commercial and when does he not become commercial? I am not in any position to argue striped bass back and forth. You have Dr. Westman in the house, and Dr. Raney.

MR. WALLACE: Please accept my apologies if I am putting you on the spot. I have no intention of doing that. The situation in the State of New Jersey regarding striped bass seems to be an enigma which is a most unusual pattern, and not found in any other particlular spot along the Atlantic Coast. I thought that possibly the people here might be interested in the situation which has arisen.

Are there other questions—not about striped bass? (Laughter) If not, we'll move along to the next paper.

MIGRATION AND FOOD OF THE NORTHERN FUR SEAL

FORD WILKE AND KARL W. KENYON
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In 1896 and 1897, C. H. Townsend and Frederick A. Lucas conducted pelagic studies of fur seals in conjunction with commercial pelagic sealers (Jordan, 1898). Between that time and 1941, no pelagic seal research was attempted. The research begun in 1941 under Dr. V. D. Scheffer was interrupted by World War II, but was later resumed in 1947 and continued through each subsequent year until 1952. Studies in the North Pacific Ocean have extended from the Pribilof Islands to the Mexican border in waters off North America and from Hokkaido to Fukushima Prefecture, of central Honshu, off Japan. These investigations provide a much more complete understanding of fur seal migration, behavior at sea, and effect on commercial fisheries than we formerly possessed. In the course of the research a total of 3 639 seals were collected pelagically and particular studies made of migration of different age and sex classes, size and growth, reproduction and food habits.

The modern pelagic studies were begun with two cruises by the *M.S. Black Douglas.* The first along the Aleutian Chain to Attu and return in the late fall of 1947 revealed that very few seals leave the Bering Sea through the westward passes of the Chain. The second from Dutch Harbor in the Aleutians to San Francisco and San Pedro Harbor, California, in 1948, revealed that seals are distributed widely in the North Pacific in late fall. In 1949 and 1950 small-scale pelagic studies, including collection of specimens, were conducted off the Japanese coast, and in 1950 and 1951 seals were collected in the inlets of the Alaskan coast. These studies have been summarized previously (Kenyon and Wilke, 1953).

The most comprehensive pelagic research program, which was conducted in the spring of 1952, involved the chartering of six *tsukimbosen,* Japanese marine mammal harpoon ships, and four American fishing boats of the purse seiner type (only two of the latter were employed at any one time.) Off the Japanese coast, biologists from Canada, Japan, and the United States participated, and off the North American coast, biologists from Canada and the United States (the Japanese, although invited, were unable to send biologists). This paper presents briefly some of the findings of the 1952 expeditions. A comprehensive report for future publication is now nearing completion.

In the springs of 1953 and again in 1954 Japanese biologists conducted pelagic fur seal studies in waters off Japan.

METHODS

One of the reasons that pelagic studies of fur seals have been so long delayed is that this work is difficult and expensive. Migration and food habits studies of seals at sea necessitate the use of ships of seaworthy design capable of remaining several days at sea and traveling 100 miles or more offshore. The Japanese tsukimbo-sen is the best ship from which to collect fur seals. A platform constructed on the bow furnishes an ideal location for observation and shooting. These ships, although about 60 feet long, are tiller steered, making it possible to follow the erratic maneuvers of frightened seals. Shotguns, 10- and 12-gauge, loaded with "0" and "00" buckshot, are used to kill the seals and they are recovered with gaffs at the tips of long poles.

On deck, weight, length, sex, whether or not pregnant, surface water temperature, time of day, the location and the total number of seals observed in the area, are recorded. Each dead seal is carefully examined for identification marks or tags, since it is impossible by any known means, other than man-made marks, to differentiate between fur seals originating on different breeding grounds (Wilke, 1951, and Anon., 1954).

The stomach of each seal is removed, labeled, punctured, and immersed in formalin solution for later laboratory analysis ashore. The right upper canine of each seal is removed, labeled, and later cleaned and studied for age determination (Scheffer, 1950a).

ARRIVAL AND DEPARTURE AT THE BREEDING GROUNDS

The northern fur seal occupies breeding grounds on the Pribilof Islands (U. S.), the Commander Islands and Robben Islands (both U.S.S.R.). The adult males haul out in May and June and the females in late June and July. Pupping is completed by the first of August. Young seals arrive on the breeding islands throughout the summer in order of decreasing age. Yearlings do not reach the Islands until September and October, and some young seals do not return to the breeding islands until they are two years old.

By mid-October, the pups have nearly tripled their weight at birth, which is about 11 to 12 pounds, and a few of the cows begin to leave. The majority are at sea by mid-December. After the cows leave, the pups remain about the breeding grounds for a short period then go to sea on their own. The adult bulls and young males (bachelors) drift away more sporadically. Some of the yearlings arrive only to leave again in a few weeks. Although it may be said that, in general, the males remain about the breeding islands longer than the females, the majority have left before the violent winter weather arrives. On the other hand, in particularly mild winters, seals, mostly males, have been recorded near the breeding islands in every month of the year.

MIGRATION OFF JAPAN

The best sealing grounds off Japan today are the same as they were in the latter part of the last century when pelagic sealing was at its height. Although seals occur as far south as latitude 36° N, the waters of greatest abundance are off Iwate and Miyagi Prefectures of Honshu Island between latitudes 38° N and 40° 30′ N. Although concentrations of seals are reported as far offshore as 300 miles by fishermen, the boats used for the fur seal investigations were unable to work that far at sea. The collecting was confined to waters within 130 miles of shore, where seals are repeatedly observed in greatest concentrations by Japanese fishermen and marine mammal hunters. Approximately 20,000 miles were covered in daylight during the studies off Japan and a total of 3,601 seals were seen, of which 2,329 were taken.

The migration of seals along the Japanese coast is later than that off North America. Seals are scarce in the coastal waters of Japan until late March or April. During the winter months, they are scattered, presumably the majority being far at sea, well off Hokkaido, and as far south as Chosi Prefecture. During April and May they appear suddenly and concentrate off Miyagi and Iwate Prefectures of central and nothern Honshu. The concentrations correspond to the areas of mixing where the warm current (Kuroshio) from the south moves north along the coast invading the cold northern current (Oyashio). Japanese fishermen, long experienced in these waters, depend primarily on water temperatures when locating seals. They demonstrated that seals are most numerous where the surface temperature is between 47° and 54° F. These surface temperatures are undoubtedly indicators of areas of upwelling where food is abundant.

Early in the season and inshore, males, predominantly young, are most abundant. As the season progresses, the females, except ages one and two, increase in numbers and concentrations appear up to 30 miles at sea. The pelagic population of fur seals off Japan is made up mostly of females but not as predominantly as off the North American coast. Of 2,329 seals taken off Japan in 1952, 1,416 were females and 913 males. Adult males were seldom seen either in waters off Japan or off North America. The probable reasons are that the commercial kill has reduced the adult male class to the least numerous component of the herd, and, in addition, the older males tend to remain in more northerly waters. If they do migrate to southern waters they precede all other age and sex classes in their northward movement. In general, the pelagic collection indicates that males precede the females in their northward movement. Seals in the two-year-old age class were the most numerous off Japan. They were followed closely by the three-year-olds. Males more than five years of age and yearlings of both sexes were poorly represented.

The fact that males above the age of five are scarce is not surprising, since the commercial kill (on the Pribilofs at least) is taken from the three- and four-year age classes. Although the yearlings should constitute the most numerous single age class, they were relatively scarce. Undoubtedly, they are scattered widely at sea.

One of the primary objectives of the 1952 pelagic investigations was the recovery of seals tagged on the Pribilof Islands. Seals totaling almost 60,000 were marked with monel or stainless steel flipper tags during 1947, 1948, and 1949, on the Pribilof Islands. Thus, in 1952, the greatest number of marked three-, four- and five-year-old seals ever available at any one time were at sea in the North Pacific Ocean. In view of the number of tagged seals available, 33.4 tags would have been recovered from the 2,329 seals collected off Japan, if the pelagic population there consisted only of seals of Pribilof origin. However, only ten tags were recovered off Japan. When considsered on the basis of age classes, these recoveries indicate that approximately 27 per cent of the seals wintering off Japan are of Pribilof origin. The limits of sampling error are from 14 to 49 per cent for 95 per cent certainty. It is assumed that migration in other age classes is similar to that in age classes three, four, and five. The tag recoveries also lead to the estimate that between one and five per cent of the Pribilof herd migrate westward in the North Pacific Ocean.

In order to obtain an approximation of the number of Pribilof seals in the waters off Japan, it was necessary to estimate the total number of seals in these waters from all sources. Since figures on the seal population of the Commander Islands and Robben Islands have not been released in recent years by the U. S. S. R., it was necessary to project old population figures in the light of our knowledge of the growth of the Pribilof herd. The Pribilof herd now numbers approximately one and a half million animals (Kenyon, Scheffer, and Chapman 1953). A second method was to estimate the total from observed densities at sea, since careful records were kept of the number of daylight miles traveled. These data lead to the approximation that the seal density in certain waters off Japan is about 1.6 per square mile. The earlier work of Stejneger (1898) was useful for compartive purposes.

The results obtained from both methods agree quite well and indicate that there are between 100,000 and 200,000 seals wintering in waters off Japan. The most probable number is about 137,000 seals.

No seals bearing marks or tags of Russian origin were recovered in 1952. However, in 1953, Japanese biologists sent us photographs of tags which are obviously not of American or Japanese origin. Several such tags have been taken from fur seals captured in nets by fishermen off Japan. Although other Russian tags have been taken from seals by Japanese fishermen in years past, none has ever been recovered in the eastern Pacific.

MIGRATION OFF NORTH AMERICA

As far as is known, practically all the seals of the Pribilof herd go south from the breeding grounds and enter the North Pacific Ocean through the easternmost Aleutian passes. From there they scatter widely. A small percentage (probably between one and five per cent) go westward and mingle with the seals from the Commander and Robben Islands in waters off Japan. The majority fan out over the eastern North Pacific. The biologists found them a thousand miles from land on a direct route from Dutch Harbor in the Aleutians to San Francisco in 1948. Some travel as far south as the Latitude 33° N while, at the same time, others are scattered through the waters of Alaska. During December, seals become fairly abundant off California and continue to occur there until May. However, sealers of the last century found January, February, and March the best months for sealing in California waters. During the same period that seals are found in the coastal waters of California, Oregon, and Washington, considerable numbers enter the inlets of British Columbia and southeastern Alaska. During the 1952 pelagic investigations off North America, 4,456 seals were seen but because purse seiners were poorly adapted to collecting seals at sea, only 686 were taken.

The exact routes which seals follow during their southward migration are not clearly defined. Apparently, after leaving the Aleutian Passes, the majority simply strike out southward and eastward. Then, after entering coastal waters, they begin to work their way slowly northward again. While they are in coastal waters, generally from 10 to 30 miles from shore, certain areas of concentration are evident. Such concentrations apparently occur as a result of up-welling where an abundant food supply is available, such as Monterey Bay, the Farallon Islands, and Portlock Bank. Assemblages of seals in straits, such as those near Sitka, Alaska, are obviously in response to an abundance of spawning herring.

Scattered seals were observed as far as 300 miles at sea off California; however, they were much more numerous nearer shore and the investigations along the North American coast were conducted, for the most part, within 30 miles of the coast. Off California seals are most numerous off Monterey Bay and in the vicinity of the Farallon Islands between mid-February and mid-April and from 10 to 30 miles off-shore. A few were found as far south as the Mexican border. In waters off Oregon, they were fairly abundant off Coos Bay and around the mouth of the Columbia River in April and off Willapa Bay and Grays Harbor, Washington, in the same month.

Although seals were numerous in the inlets just south of Sitka, Alaska, in the early spring of 1950 and winter of 1951, they were scarce in June of 1952 in the Sitka area and along the eastern rim of the Gulf of Alaska, but were numerous westward on the Portlock Bank. From the Gulf of Alaska the seals apparently do not move westward through Shelikof Strait, between Kodiak Island and the Alaska Peninsula, but stay farther at sea as they progress toward the Aleutian Passes and the Bering Sea during June and early July.

The age and sex composition of seals frequenting different areas at sea varies considerably. Off California, the collection consisted of 98 per cent females, mostly adult. Off Oregon and Washington, it was 96 per cent females but the proportion of young females increased. In the 1952 collection off Alaska, males constituted 33 per cent of the total kill. However, winter and early spring collections totaling 148 animals taken at random near Sitka were composed of 100 per cent adult females.

In general, it appears that adult females migrate farthest south while males and yearlings of both sexes migrate south of Oregon only to a minor degree. In the stormy winter of 1948-49, 29 tagged fur seals less than a year old washed ashore on the Oregon and Washington coasts (Scheffer 1950b). Already in the winter of 1953-54, ten tags recovered from seals of the same age have been reported from Oregon, Washington, British Columbia, and Alaska. Since only 10,000 pups out of approximately 500,000 on the Pribilofs were tagged in 1953, this indicates that the rigorous weather conditions this winter have killed many young seals.

The 1952 studies reveal that on the Portlock Bank, while seals are moving north and westward toward the Pribilofs in June, the older seals precede the younger and within each age class, the males precede the females. Also, pregnant females precede the non-pregnant. A similar order of arrival is observed on the Pribilof Islands.

FOOD OF FUR SEALS

Seals appear to feed mainly during the hours of darkness when small demersal species are found near the surface. Since most seals are collected at sea during the daylight hours, the collections contain a high percentage of empty stomachs. Unfortunately, the stomachs of seals killed on the Pribilof Islands are almost invariably empty.

Of 686 stomachs collected in 1952 off North Aemerica, 35 per cent contained food. Of 2,312 collected off Japan in the same season, 49 per cent contained food. In both areas, the stomachs having the greatest quantity of food were taken in the early morning or late afternoon. Those taken near the middle of the day were most often empty. Stomachs otherwise empty frequently contain the beaks and eye lenses of squids which remain in the folds of the stomach after all else is digested. The investigations indicate that the species composing the dominant food items are quite different in different areas. Also, that at different seasons in the same area, different food items predominate. In general, it can be said that fur seals feed on the open sea, often over very deep water, and subsist mainly on small schooling fish and squid of little or no commercial value.

Bering Sea. Little recent investigation has been made on food consumed by seals in the Bering Sea. The most information has been obtained from spewings on the hauling grounds and rookeries. Fish bones and partially digested material are disgorged most frequently where young males consort. The disgorged material consists almost entirely of the bones of fishes in the cod family, Gadidae. Whiting (*Theragra chalcogramma*) the predominant species, is accompanied by small cods, such as tom cod (*Microgadus proximus*) and arctic cod (*Gadus macrocephalus*). No trace has been found of the "seal fish" reported by Lucas (1899) from the Bering Sea. This was later identified by Chapman (1943) as *Bathylagus.* A seal collected by salmon investigators in a gill net off Atka village contained a salmon (*Oncorhynchus* sp.), whiting, and squid, (*Decapoda*). This stomach analysis gives the impression that the seal had been feeding on whiting and squid until a netted salmon was held waiting for it.

Additional summer food habits studies of seals in the Bering Sea are needed, particularly since food supply may be one of the factors holding the seal herd at a nearly constant level. It is interesting to note some of the results of exploratory fishing activities in the vicinity of the Pribilofs. In 1941 dragging operations between St. Paul and St. George Islands in 33 to 42 fathoms revealed that: "The quantity of flatfish was greatly reduced. . ." (Anon. 1942). Since the fur seal is known to descend to at least 40 fathoms (Scheffer 1946), it is possible that the seal herd is responsible for the depleted bottom fish population in this area.

However, a very different condition was found to exist in relation to salmon. Exploratory gill net operations were conducted in the Bering Sea during June and July of 1940 and a number of sets were made near the Pribilof Islands. (Stations extended in a line from islands of the Aleutian Chain, by way of the Pribilofs, to Nunivak Island.) Since there are no salmon streams on the Pribilofs, it is interesting that in the vicinity of these islands, "Salmon were taken at every station fished. . . . the largest catch (328 salmon) was made at station 32, one of the stations located between the Islands" (Barnaby 1952). Other catches within the feeding range of fur seals on the breeding grounds were good. For example, at distances from the islands of 17 to 57 miles, respectively, 193 and 155 salmon were taken in gill net sets. The average take dropped as the distance from the islands increased until waters near spawning streams were reached, when the catch increased.

Lucas, in his studies of fur seal stomach contents, found that in the Bering Sea, of 373 stomachs examined, squids, (*Gonatus fabricii*), whiting, and "seal fish," in that order were the most important items in the diet of the fur seal.

Gulf of Alaska. Recent examination of 116 stomachs containing food and 272 empty ones gives a much different picture of the food of seals in the Gulf of Alaska, than was obtained from examinations made in 1896. In April, 1896, the seals were feeding principally on squid, varied occasionally with rockfish (*Sebastodes*), salmon, and whiting. In 1952, eulachon (*Thaleichthys pacificus*), made up nearly 82 per cent of the food, and another smelt, the capelin (*Mallotus villosus*), composed 10 per cent. Lesser percentages were contributed to the diet by hake (*Merluccius productus*), whiting, and squid. The difference between these two samples may be a seasonal one which occurs between April and June, the respective months of the 1896 and 1952 collections. Whales, porpoises, shearwaters, fulmars, gulls, and murres, as well as seals respond to the wealth of food furnished by the eulachon in the Gulf of Alaska in June. Availability apparently determines the choice of food.

Southeast Alaska and British Columbia. A few thousand adult females regularly enter West Crawfish Inlet from late December until late March, to feed on herring (*Clupea pallasi*). All but two of 148 seals collected here had fed exclusively on herring. These two, which were believed to have just entered the Inlet from the sea, contained whiting and squid. Herring continues to be a principal food of spring migrating seals, as one proceeds southward along the British Columbia coast. The gathering of seals in the enclosed waters of West Crawfish Inlet represents an abrupt departure from the usual pelagic existence of seals when they leave the breeding islands.

Washington, Oregon, and California. Little data is available on food habits of seals off the Washington coast. In order of decreasing volume, the species found in 10 stomachs were whiting, eulachon, shad (*Alosa sapidissima*), rockfish, herring, and anchovy (*Engraulis mordax*).

Twenty-two stomachs were collected off Oregon in 1952. In order of decreasing volume, the species were salmon, hake, rockfishes, jacksmelt (*Atherinopsis californiensis*), shad, herring, squid, and sable fish (black cod). Salmon, although representing the greatest volume, was found in only five stomachs.

Previous to 1952, only two stomachs containing food had been collected off California. Of the 199 collected in 1952, 93 contained food. Thirteen species of fish were identified, nine of them of commercial value and one species of squid. Since lantern fish are an important item in the diet of fur seals off Japan in the same latitude as collections from California, it was expected that they would occur in stomachs from California; especially, since observers have seen fur seals pursuing lantern fish in California waters (Hanna 1951, McHugh 1952, and Follett 1952). However, none was found. The most important items of food off California were found to be (by volume) the northern anchovy, 16 per cent; the jacksmelt, 14 per cent; the hake, 13 per cent; and rockfish, 10 per cent.

Iwate, Miyagi, and Aomori Prefectures. During February, when the collection of stomachs for food studies was begun, few seals were present. Thus, the kill was small and the results practically insignificant. However, it is interesting to note that in this month and in no others, saury (*Coloibis saira*), entered the diet of the fur seal. The saury is an important food fish for the Japanese but probably does not suffer from fur seal depredation since the fur seals occur north of the main saury fishing areas during the fishing season.

The most significant food habits studies were conducted during late March, April, and May, when the seal migration off Japan is at its height. The results show that the fur seals' diet is not uniform. Lantern fishes (Myctophidae), of several species, were the food item of greatest importance. A single species, *Notoscopelus japonicum,* formed 99 per cent by volume of the lantern fishes and 60 per cent of all food eaten by fur seals off Japan. Lantern fishes are not utilized commercially by the Japanese. The commercially important large squid, *Ommastrephes sloani pacificus,* was the second most important single food item, 17 per cent of the total volume. The small luminescent squid, *Watasenia scintillans,* and the Japanese anchovy

(*Engraulis japonicus*) each contributed eight per cent to the total volume.

Thirty-one per cent of the total volume of all stomach contents examined were of commercial importance in the Japanese fishery. Off Miyagi Prefecture, 18 per cent of the food eaten by seals consisted of commercially used species, off Iwate and Aomori, 31 per cent.

Hokkaido. The waters off Hokkaido are one of Japan's most productive salmon fishing areas. Since it has been claimed that salmon are the subject of heavy seal predation, the waters off Hokkaido were visited in January, 1949, and again in May of 1950, but seals were scarce. Accordingly, the 1952 investigators hunted seals intensively off Hokkaido in June. However, seals were scarce in that month also, only 47 being taken in 27 boat-days of hunting. Four of those taken contained salmon, which constituted 58 per cent of the food volume in all stomachs. In all commercially used species constituted 76 per cent of the food found in the 1952 collection of seals from waters off Hokkaido. In winter whiting and squids were found to be important items of food and in the spring, lantern fish and squids.

It has often been suggested that the fur seal herd poses a threat to the salmon industry. For this reason, efforts have been made, both off Japan and off North America, to collect seals in areas where salmon occur. From a total of 2,779 seal stomachs collected in recent years off Japan, five, or 0.2 per cent, contained salmon. Off North America, 2,129 stomachs have been examined. Among these, 69, or 3.2 per cent, contained salmon. It thus appears quite evident that the fur seal feeds on salmon to only a minor degree. When salmon are most available in waters off southeastern Alaska and British Columbia during the spawning season, the fur seals are gathered about the breeding islands in the Bering Sea.

Even though experimental gill netting operations show that salmon are quite abundant near the Pribilof Islands during the fur seals' breeding season, available data give no indication that salmon enter the fur seals' diet in this area.

Non-commercial species formed major portions of seals' diet along north sides of the Pacific, but the dominant species in each area were different. For example, 91 per cent of the food volume taken from seals in Alaska waters was composed of capelin, while jack smelt was one of the predominant food species off California. However, no fishes of either the smelt or silverside families occurred in the stomachs of seals from waters off Japan. While lantern fish composed 69 per cent of the fur seal food off Japan, they did not occur in stomachs taken off North Ameria.

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DISCUSSION

DISCUSSION LEADER WALLACE: There are many points that Mr. Kenyon pointed out that I think are of considerable interest. The one that impressed me was the great concentration of a single sex in a given area. Is there any explanation for this heavy concentration of a given sex in one specific area?

MR. KENYON: This was a concentration of a hundred per cent adult females near Sitka. We can't figure out any good reason for that. Of course, we know that the adult male doesn't go down that far. Perhaps the adult females, most of them being pregnant, would want to get to an easy food supply. That may have had something to do with it.

A CLUE TO THE EELGRASS MYSTERY

ALEXANDER C. MARTIN[1]
Patuxent National Wildlife Refuge, Laurel, Maryland

Ever since the eelgrass catastrophe of the early thirties, there has been continuing speculation about its cause or causes. Though many recognized the mystery as having been solved in 1934 when Renn (1936) discovered the parasite *Labyrinthula* on eelgrass, a number of biologists in Europe and America have doubted that parasite damage is the whole explanation. Notable among these was the late Dr. Neil E. Stevens (1936, 1939) who regarded widespread, simultaneous losses of eelgrass as suggestive of an extensive environmental influence. Various causative factors have been suggested by different people but, strange to say, the rather obvious one of precipitation extremes seems to have escaped serious consideration.

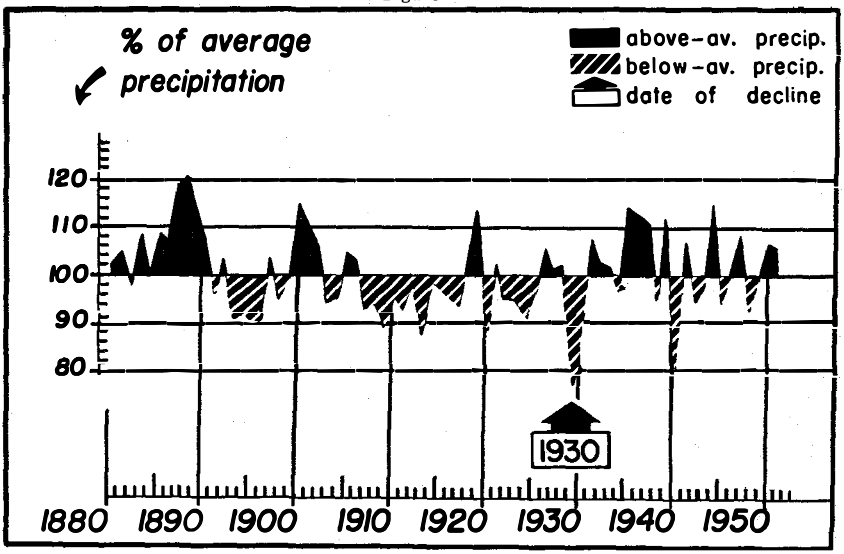
The assumption that extremes of low and high precipitation may play an important part in eelgrass declines is based on a series of seven correlations between weather records and past disappearances of the plant mainly as reported by Cottam (1934, 1935). Evidence supporting the theory has been obtained from areas where heavy losses of eelgrass have occurred, namely, eastern United States and western Europe. For present purposes, states which serve as watershed for the bays and estuaries in which eelgrass grows along the Atlantic Coast have been grouped into three regional units similar to those used in weather reports: New England, Middle Atlantic, and Virginia-North Carolina.

Figure 1 depicts variations in annual precipitation, below and above average, in the entire Atlantic Coast area from Maine to North Carolina, from 1880 to 1953. The two lowest points on the chart, at 1930 and 1941, qualify as droughts according to the weather-report practice of classing deficiencies of 15 per cent or more as droughts. The 1930 period of dryness was an exceptional one and was ranked by Hoyt (1936) as the "No. 1" drought of the "Humid States." For this region, it set an all-time record precipitation of 25 per cent below par. In addition, temperatures were high, salinity in bays and estuaries was above normal for nearly two years, and brackish water limits in rivers shifted far upstream. In the Susquehanna River, the brackish zone moved upstream nearly 30 miles, and in the Potomac, about 16 miles (Goldman, 1931).

Correlated with this worst-of-all Atlantic Coast droughts was the worst eelgrass decline of modern times. The 1930 disappearance, like

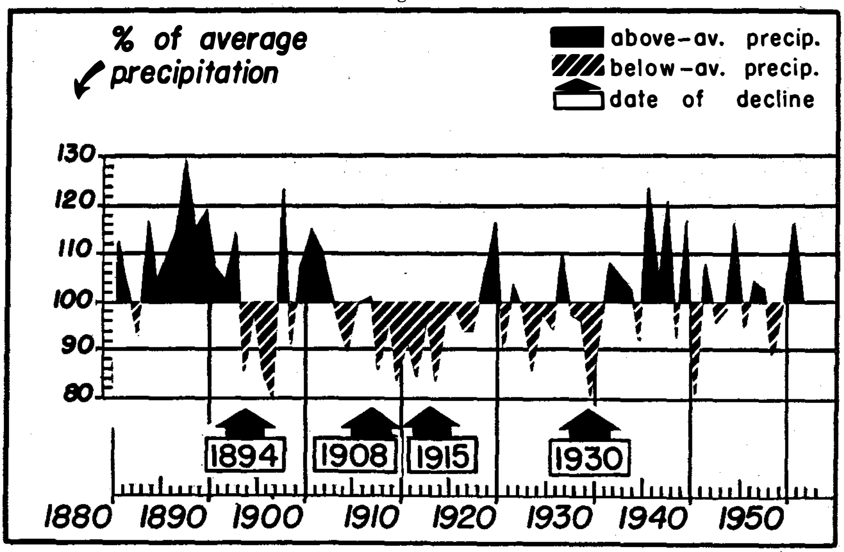
[1]In the absence of Mr. Martin, this paper was read by Dr. Clarence Cottam.

Figure 1



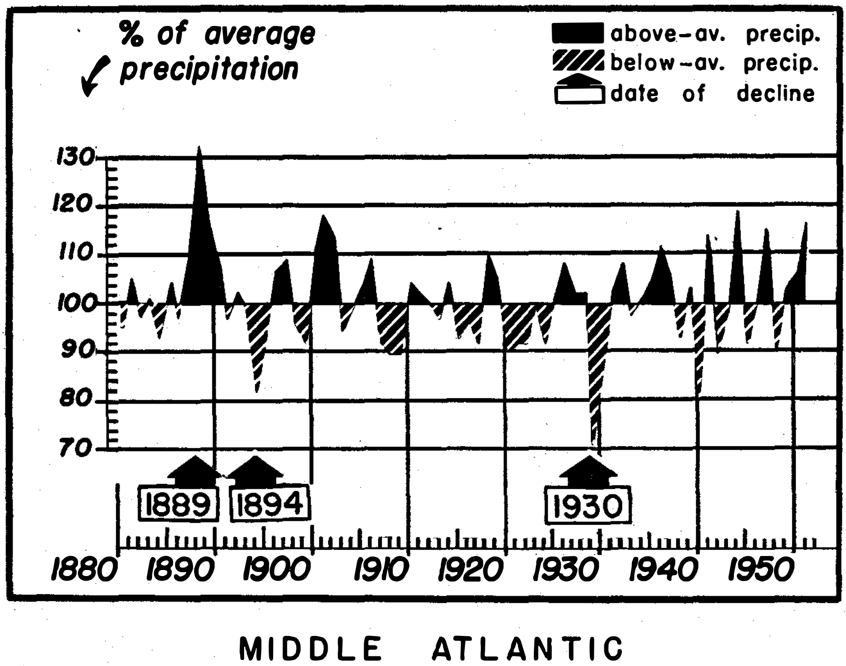
ATLANTIC
(Me. to N.C.)

Figure 2



NEW ENGLAND

Figure 3



those of other dates indicated on following charts, is denoted by a broad arrow-point attached to a blocked-in date. Recovery of eelgrass from this catastrophe was so slow that if another widespread setback occurred during the 1941 drought, it was unnoticed or unreported. Consequently, no 1941 decline is indicated on this or following regional charts.

The New England chart (Fig. 2) shows that in this region the 1930 drought was not so severe. However, several additional droughts or near-droughts, some of them in close succession, are evident. All four dates (1894, 1908, 1915, and 1930) in which eelgrass decline was reported by Cottam for New England correlate with periods of marked deficiency of precipitation.

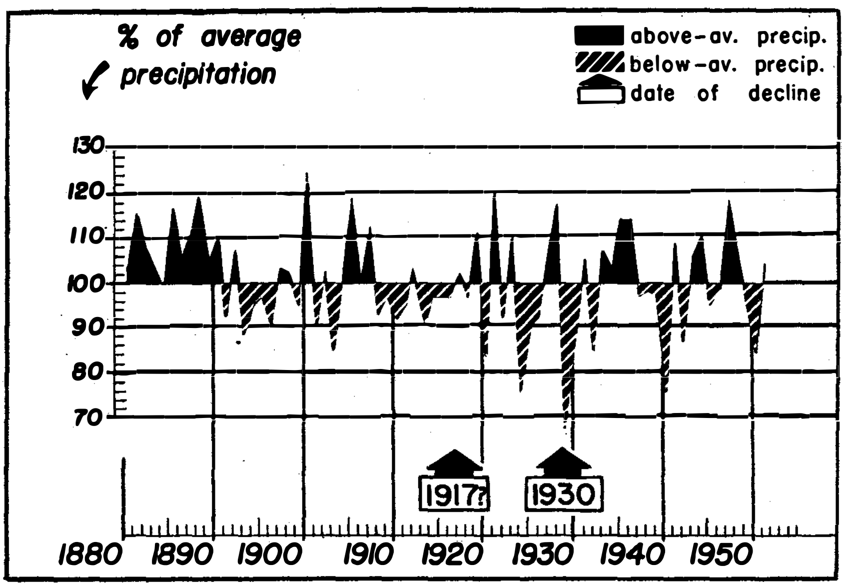
Besides the 1941 drought, discussed above, the Middle Atlantic chart (Fig. 3) includes two periods of deficiency which correlate clearly with disappearances of eelgrass: 1930 and 1894. The 1894 decline was noted by observers in several places and appears particularly significant since it ties in with the "No. 2" drought of the "Humid States" (Hoyt, 1936). Thus, not only did the No. 1 drought (1930) coincide with the No. 1 disappearance of eelgrass, but also the

No. 2 drought (1894) was followed by a major loss of the plant. The one additional eelgrass decline reported in this region occurred during the exact opposite of a drought—a 32 per cent excess of precipitation accompanying the disastrous Johnstown flood of 1889.

Though the Virginia-North Carolina chart (Fig. 4) does not give effective support to the weather-decline theory, it is included to complete the regional picture. The 1930 drought was extreme in this section and was followed by a marked reduction of eelgrass but the 1917 decline reported in Pamlico Sound does not show direct correlation with precipitation extremes.

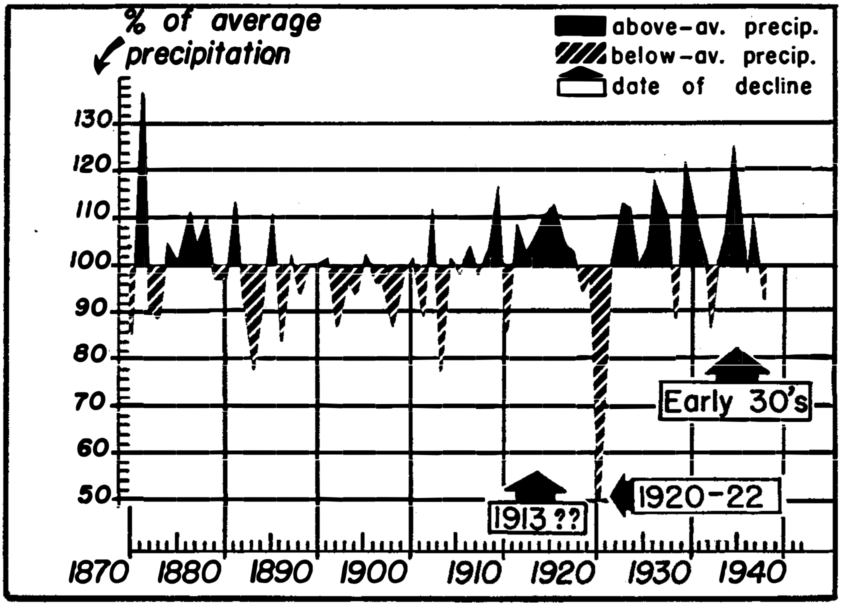
The precipitation chart for western Europe (Fig. 5) is based on an averaging of data from six west-European stations (Aberbeen, Greenwich, Utrecht, Paris, Lyons, and Marseilles) having weather records that extend through the last quarter of the nineteenth century. Severe losses of eelgrass were reported in western Europe, particularly Britain and France, during the early thirties—about the same time as the disastrous disappearance in eastern North America. However, the chart shows no serious-appearing droughts during this period. Instead there was above-average precipitation, with a 22 per cent excess in 1930 and other high peaks shortly before and after this

Figure 4



VIRGINIA—NORTH CAROLINA

Figure 5



WESTERN EUROPE

date. Conceivably, these extremes may have been detrimental to eelgrass.

Though no drought is evident on the western Europe chart during the early thirties, an extremely severe one, far worse than any ever recorded on our Atlantic Coast, is indicated by the 50 per cent dip in 1921. And apparently, it was at this time that the major eelgrass recession in the region began. Though the British biologist, Dr. R. W. Butcher (1941), makes no mention of the 1921 drought, significant correlation with it is suggested by his statement that "So far as England was concerned the disappearance of *Z. marina* had been noted long before 1932, and the concensus of opinion was that dying out was first noticeable in the period 1920-2." His comment continues: "There were, however, the reliable reports mentioned above which show there must have been an obvious decrease larger than usual in 1931 and 1932, but it is erroneous to suppose that decrease first occurred in 1930 and 1931."

The additional European report of disappearance seems to be a dubious one. According to "A crop report from France. . . 1913 was a year in which but little eelgrass was produced" (Cottam, 1934).

TABLE 1. CORRELATIONS BETWEEN REPORTED EELGRASS DECLINES AND UNUSUAL PRECIPITATION CONDITIONS

Date of decline	Place	Precipitation Conditions
1889	Chesapeake Bay	Flood; 32% excess for region
1894 (about)	N. Eng. & Mid. Atl.	Drought "No. 2" in "Humid States"
1908	New England	Near-drought; 14+% of deficiency
1915	Paponesset Bay, Mass.	Drought; 16% deficiency
"1920-2"	England	The extreme drought of 1921
1930-32	Eastern N. America	The severe drought of 1930
Early 30's	Western Europe	Excess precip.; 22% in 1930

Since extent of harvesting and marketing of eelgrass depends nearly as much on economic and social circumstances as on current abundance of the plant, it would appear that the 1913 report does not definitely denote eelgrass decline nor does it present real contradiction to the hypothesis. In this regard, it resembles the reported reduction of eelgrass in Pamlico Sound in 1917. Probably a local decline did occur in the Sound at that time, but conceivably it may have resulted from storm-induced changes in the barrier reef. More definite information on these two negative instances may either eliminate them as seeming exceptions or may change them into clear-cut contradictions. Meanwhile, they, of the whole series of nine disappearances reported by Cottam, are the only ones which do not confirm, in some degree at least, the concept of correlation between precipitation extremes and eelgrass losses.

The seven reported disappearances which support the theory are summed up chronologically in Table 1. At best, they constitute strong circumstantial evidence; hardly proof. It seems particularly significant, however, that the three worst declines in the areas concerned accompanied the three worst droughts (1894, 1921, and 1930). Whereas it seems probable that such declines have resulted from associated conditions favorable to the eelgrass parasite, it appears equally logical to assume that a decline such as the 1889 one in Chesapeake Bay, following the Johnstown flood, may reflect direct detrimental effects from factors such as excessive freshness, excessive turbidity, or submergence under silt. Future studies under controlled conditions may give conclusive verdicts on these points and on the role (if any) of precipitation extremes as a factor in eelgrass declines.

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DISCUSSION

DR. HARRISON LEWIS (Nova Scotia): It happens that I was looking over some of my old records and correspondence on this subject just a short time ago, and refreshed by menory, not knowing that this paper was to be presented.

I noticed when I first began to correspond with European marine biologists and botanists about the eelgrass conditions there—which I think was about 1931—I was instigated by the change that was rapidly taking place on the eastern coast of North America. The first letters I had back from Europe—I think from both England and France—were to the effect that they couldn't observe any change in the status of eelgrass on the European coast.

A year later the story was very different, but they did not appear to be aware of any significant diminution in the eelgrass stand at the time when is was already marked in North America. When it did come on a year or so later, it was devastating, and abrupt.

I find it somewhat difficult to follow the reasoning suggested in this paper in connection with the Gulf of St. Lawrence, and especially with the St. Lawrence River estuary. On account of the outflow of fresh water in those areas, the salinity is never as high as in the open Atlantic, and in the estuary of the St. Lawrence it is very low.

I have never heard of any serious diminution of eelgrass prior to the early thirties, but the eelgrass disaster of the early thirties was very marked in the Gulf of St. Lawrence and even in the St. Lawrence estuary, where it would be difficult to attribute it to increased salinity.

We are still without any clear explanation, as far as I am concerned, as to what caused this very abrupt and rapid destruction. I would be glad if anyone could inform me as to whether the type of or cause of destruction was known to be present on the Atlantic coast of North America prior to about 1930. I understand that it was present on the Pacific coast, and continued to be so, throughout the eastern eelgrass disaster, without causing comparable destruction in the Pacific, but whether that organism was recognized as being present in the Atlantic prior to that year, I don't know.

DR. COTTAM: Thank you. Dr. Lewis has written quite a number of papers on eelgrass himself, and he and I have collaborated on one or two, as I recall it.

In fairness to Dr. Martin, I should say he does not consider this positive proof by any means. He said that so far as he is concerned, he merely submits it as one more hint. He says, "I don't know whether the subsequent facts that may be uncovered will support or go contrary to this thing."

There were nine periods of eelgrass scarcity, and seven of those showed marked correlation; two did not. One of the latter was in 1917, in Pamlico Sound—it could be explained by local storms; another one was in Europe in 1913—my basis of that being listed was merely a report of the amount of eelgrass sold. As you know, eelgrass enters into trade as packing and for quilts, and for quite a number of other things. There could have been a lot of economic problems in 1913 which may have influenced the decline, and there may have been no diminution in actual production of eelgrass in the ocean or along the oceanside.

My memory is that Renn, as I recall, came to this conclusion in his paper: The species of *Labyrinthula* found on the east coast was described by him at that time; subsequent to that, the same organism was found on the Pacific Coast. I think that is to be expected, because ships traveling between the Atlantic and the Pacific often carry water as ballast, and this minute organism certainly would have been in this water that was carried as ballast. Therefore, to find it on the Pacific Coast was to be expected. Most of us expected that it soon would be found there, and it was found. Whether the organism was less variable on the Pacific Coast or whether it was because of a different environment, or whether the plant on which it subsisted was not so susceptible to *Labyrinthula* on the West Coast, only the Lord knows, but that is not an uncommon thing in the history of disease, that one race of a plant, one variety of a species, may be quite immune. For instance, some forms of chestnut may do very well while our native American chestnut might be knocked for a loop every time the blight hits it. This may be the same thing.

Whether the precipitation records in the Gulf of St. Lawrence,—Seems to me the one thing we don't have is salinity tests of the water, so I don't know.

DR. LEWIS: That would indicate, then, that there isn't any record of this type or species of *Labyrinthula* in the Atlantic prior to the eelgrass disaster. Possibly it may have been there.

DR. COTTAM: That is my memory.

DR. LEWIS: I appreciate the continued efforts of Dr. Martin, who tried to solve this problem, and we should all like to see it solved. It is a very enjoyable role to approve of an obvious solution, perhaps more enjoyable than to continue to be a somewhat agnostic. It is very nice to have an additional hypothesis added to the number that have already accumulated.

While we are at it, perhaps I might add another one. As a matter of fact, I was rash enough to put it in print quite recently, but I very distinctly tagged it as purely hypothesis.

It seems to me it would be very nice if it were true, because it can be made to correspond with the known facts. Perhaps this will give us all something more to chew over in our minds.

It could well be that this type of *Labyrinthula* was a native of the Pacific Coast, not the Atlantic, and that the ancestor reached a mutual adjustment there years ago. That is why there was no great outbreak there; the two organisms were adjusted as host and parasite so commonly are. How did it get to the Atlantic, where it never had been found before?

There was one great change that might possibly have been an effective factor, and that is the construction of the Panama Canal. When water ballast was carried from one coast to the other around the Horn, it took too long for the organisms to survive the trip. The construction of the Panama Canal shortened the time very much. Certainly, it could be possible to carry marine organisms from one coast to another in much shorter periods of time than was possible before, so it might have been brought from the Pacific to the Atlantic that way, and eventually it increased sufficiently to cause an observable eelgrass disaster, following which, of course, it would be quite easy for the ballast to be taken across the Atlantic to cause a disaster on the European coast somewhat later than the North American disaster.

This is just another fairy story.

DR. COTTAM: The only hope I hold for the fairy story is that since man started to travel, he used water, which far antedated the opening of the Panama or the Suez canals. I don't know.

MR. BARICK: I would like to ask the degree of salinity within which eelgrass is not harmed. I rember when the engineers opened the locks at Great Wales, and let the waters go near Elizabeth, in North Carolina. That period, as I recall, did not coincide with the period of reduced precipitation.

DR. COTTAM: That's correct.

MR. BARICK: In Britannic history, a fresh water plant has frequently been called eelgrass. Now, the plant down in Back Bay, down in our bailiwick down there, is not eelgrass as we were talking about it now. You're talking about two different plants. What you're talking about is a fresh water species of plant down in Back Bay.

For instance, there is the "wild celery." That is a fresh water species, entirely.

That species will not tolerate more than 10 per cent sea salinity; in fact, it will die before it reaches 10 per cent.

There is one disadvantage of common names. The common name, eelgrass, is also more commonly referred to as this marine plant that grows along the coast in highly saline waters, and you are dealing with two entirely separate species of plants.

CHAIRMAN WESTMAN: I simply would like to ask Dr. Cottam: Have there been any experiments on *Labyrinthula* in an attempt to find out what might be the conditions to make it epizootic?

DR. COTTAM: Doctors Renn and Young both did work along that line, but frankly, that is out of my realm. They did not work on it very long. They did carry on a series of experiments.

I well remember in my consersations with Dr. Renn, he brought in plants—we helped get plants, ourselves—to see if he couldn't develop an epizootic in those. We would have to get from him the details of how he carried that on and the results of it. I'm sorry that I don't know the details. He was not too successful in that.

I might say that we, ourselves, on many occasions introduced Pacific Coast eelgrass in the Altantic Coast, and tried to reestablish the cause of the relationship of eelgrass to the scallops, to the various mollusks and waterfowl along the coast. A number of species of birds as well as a number of other littoral forms have a close correlation, live in the same ecological zone, and are either dependent on the food or the environment which the eelgrass provides.

When eelgrass went out so rapidly, it left a void, and there were tremendous changes along the coast.

On a number of occasions we introduced the West Coast plants; I think we made 15 or 20 attempts. We didn't get very far. It seems to me that possibly the principal explanation was that there is a difference in virulence, or else there is a difference in the susceptibility of the two groups of plants to withstand the devasting effects of the epizootic.

I think you who are interested in eelgrass will be interested in this one comment. Eelgrass has made a marked recovery, and there are a number of places along our coast where there has been a marked improvement. I can't give you too much information about Canada; Dr. Lewis will give you that.

However, there are a number of unexplained voids along the coast. Over much of the outer barrier reef of the Delaware-Maryland-Virginia peninsula it is still almost zero, with almost no return. In fact, most of the early recoveries were in areas of reduced salinity. That is just a statement of fact, but at the same time there were a number of areas, particularly along the coast of Maine and along the New England coast, where marked recovery occurred in highly saline waters, so it is back to normal there, and is not a constant by any means.

DR. LEWIS: In response to that invitation, I must say that in Nova Scotia the eelgrass has recovered to a marked degree and is still improving noticeably, year by year.

DR. COTTAM: We have many places along our coast where I would say the eelgrass is as abundant as it used to be.

TECHNICAL SESSIONS

Wednesday Morning—March 10

Chairman: ANTON DE VOS
Lecturer, Department of Entomology and Zoology, Ontario Agricultural College, Guelph, Ontario, Canada

Discussion Leader: RAYMOND F. DASMANN
Department of Biology, Duluth Branch, University of Minnesota, Duluth, Minnesota

BIG-GAME AND FUR RESOURCES

INTRODUCTORY REMARKS

ANTON DE VOS

I feel that this morning we have an excellent set of papers to present to you, and may I bring to your attention that the number of papers which have been submitted during the last few years shows a definite increase in interest in big game and fur-bearing animals on the North American Continent. I am certainly very happy to see this trend. Research on big game and fur-bearing animals has been neglected as compared with the work on waterfowl and other game. As a matter of fact, many more papers were submitted for this particular session than could be used and unfortunately we had to turn down some very excellent papers.

Regarding big game management, I would like to say that it is necessary that we pay more attention to herd and range management because hunting pressure is rapidly increasing and better techniques are needed. Without more refined techniques we will not be able to meet the demand. Several of this morning's papers will discuss problems regarding range and herd management.

In regard to research and management of fur-bearing animals, we are in serious trouble, on some species at least, because the price of pelts has dropped. This situation is particularly serious in the case of beaver. The price has dropped to such a low level in many parts of North America that trappers do not go into the bush any more to harvest the pelts, and this results in overpopulation and outbreaks of epizootics. This also results in a serious threat to the pelt industry, particularly in parts of Canada.

I think the papers which will be presented on beaver management this morning will highlight this situation. Certainly there are other species of furbearers which result in similar difficulties. I feel that it would be advisable to try to find why our fur has such low value, whether it is competition with the artificial fur industry or whether it is lack of purchasing power of the U. S. market or even the North American market, or whether it is a matter of the whims of women. If the latter would be the case, there is nothing to fear, but I am afraid, myself, that there are other factors involved in this thing and I certainly would like to suggest that biologists working on fur management try to look into this situation more than has been done in the past. I would also like to suggest that our technicians on fur management get in touch with the fur industry, in other words, the people who manufacture the product in such centers as in Chicago, and try to establish some sort of a scheme. Maybe if they would take a slight cut in prices, it would prove to be advantageous to both the middleman and the trapper in the bush.

PROGRESS ON A MARTEN LIVE-TRAPPING STUDY

FLETCHER E. NEWBY

Montana Fish and Game Department, Helena

AND VERNON D. HAWLEY

Montana Cooperative Wildlife Research Unit, Missoula

Live-trapping provides an excellent opportunity for obtaining quantitative information on the ecology of the marten (*Martes americana*). De Vos (1952) suggested that "A long-range live-trapping study of fisher and marten should be undertaken to obtain more information on sex ratios, home range and population densities in different habitat." Preliminiary findings from such studies were reported by de Vos and Guenther (1952), but otherwise the literature is almost devoid of truly quantitative data. Accurate information relating to population dynamics is seriously needed to guide restoration of depleted areas and to place management on a sustained yield basis. A study aimed at obtaining this information was begun in August, 1952, and will continue indefinitely. While it is not the purpose of this report to present definite conclusions based on one year's data, methods and preliminary findings from this investigation through September, 1953, are presented for the use of other workers involved in marten management and research.

STUDY AREA

Selection of a six-square-mile study area in Glacier National Park, Montana, was based on ease of access and indications of an abundant population of marten. This area is located west of the Continental Divide in the drainage of the North Fork of the Flathead River. Summer tourist travel is light and deep snows isolate the area in winter. The topography consists of foothill terrain extensively modified by valley glaciation. Elevations range from 3,500 to 4,800 feet. Although climax vegetation for most of the area is spruce-fir (*Picea engelmanni-Abies lasiocarpa*), very little of this vegetation type is now present. Recurrent forest fires occurring on various exposures have created a high degree of interspersion of seral stages and age classes. Portions of the study area recently burned are dominated by stands of lodgepole pine (*Pinus contorta*) of varying ages. Components of other seral communities are Douglas fir (*Pseudotsuga taxifolia*) and western larch (*Larix occidentalis*) with ponderosa pine (*Pinus ponderosa*) assuming dominance on southwest slopes. Vegetation of open meadows is predominantly timothy (*Phleum pratense*). Aerial photography and field reconnaissance will result in preparation of a detailed type map which will be correlated with marten activity and densities.

METHODS

Collapsible live traps produced by the National Live Trap Company, Tomahawk, Wisconsin, in the 6 by 6 by 19 inches model have proved to be most efficient. Trap sites were carefully prepared in fallen logs and rotten snags with special chisels. Sets of this type functioned effectively even in adverse weather and offered excellent protection for captured animals. Experimentation with many types of baits has proved kippered herring to be most satisfactory. A scent composed of rotted fish and oil of catnip was used to lure the marten to the vicinity of the trap. The combination of techniques described has been highly selective for marten with relatively few captures of other animals. Other methods involving a variety of baits, and ground sets were quite attractive to various rodents and birds.

Captured marten were handled through use of a wire cone which was attached to the opening of the trap. When the door was opened, the animals usually entered the cone freely, but occasionally the use of force was required. The compressed cone was then detached from the trap with the marten held securely for examanition. Numbered fingerling tags produced by the Salt Lake Stamp Company, Salt Lake City, Utah, were placed in each ear for future identification. Weights were taken to the accuracy of 25 grams with the marten held in the cone. Data recorded for each capture were tag numbers, weight, sex, condition of aging characters, indications of reproductive status, date and location of capture, and behavior.

Strap type fingerling tags used for marking marten during this study are believed to be more successful than button-type tags (Reynolds, 1953b) or battery-operated tattoo. No effort was made to apply the tags under aseptic conditions, and some infection and sloughing of tissue was noted at the site of insertion. Tags were known to be retained in the ear for a period of at least three years on one occasion, while in a few other instances individual tags were lost in a matter of months. Continued experimentation with redesigned tags to eliminote pressure on the ear, with other types of tattoo and sterilization of the site of application will likely lead to improved methods of marking.

Difficult terrain, dense vegetation, size of the area, and lack of personnel prevented establishment of a true grid system of trap location. Trap lines approximately one-third to one-half mile apart were run from east to west, utilizing existing trails wherever possible. Trap sites were made along these lines at intervals of one-eighth to one-fourth mile (Figure 1). Selection of trap locations was based on indications of marten activity near these sites. Plotting of trap sites on aerial photographs was accomplished by pacing along compass courses from ground reference points. Fluctuations in weights of individual marten captured frequently over extended periods indicated the inadvisability of long trapping periods. In order to minimize possible adverse effects, traps were moved from one portion of the area to another after a week's operation.

Sex determination was accomplished by palpation to establish the presence or absence of a baculum or through observation of the vulva. The experienced observer can, however, usually distinguish between sexes on the basis of larger over-all size and broader head of the male.

Although techniques for aging marten from skeletal material have been suggested by Marshall (1951), these are of limited application in the field. The differential in weight between juveniles and adults was useful in aging for a limited period. According to Brassard and Bernard (1939), young marten attain adult weight at about three months of age. Our findings indicate that juvenile females usually reached adult size at this time but that juvenile males did not become of adult size until approximately one month later. The softer appearance of the juvenile pelage was a useful aging character until late September when growth of the winter coat had progressed considerably. Examination of the development of the sagittal crest (Marshall, 1951) and base of the baculum by palpation was utilized in aging males. Reference to materials from known-age marten showed that adult males had a pronounced enlargement of the corpora cavernosa and basal portion of the baculum while juvenile males lacked this development (Figure 2). Information on the nature of this difference was provided by the experimental work of Wright (1950) on long-tailed weasels (*Mustela frenata*). He obtained indications that increased production of androgens connected with attainment of sexual maturity stimulated development of the juvenile baculum to the adult type. Aging of females involved palpation of the sagittal crest with the addition of examination of the mammae. Females which had produced and suckled young had large, conspicuous mammae. Mammae of juvenile females were so small as to be difficult to observe even with extended, careful examination. Some females were tentatively classified as yearlings on the basis of greater development of the sagittal crest and lack of conspicuous mammae. Age determination of young marten was uncertain in the period between the attainment of adult size and the development of fully adult aging criteria. There is, however, some promise that with continued investigation and with more

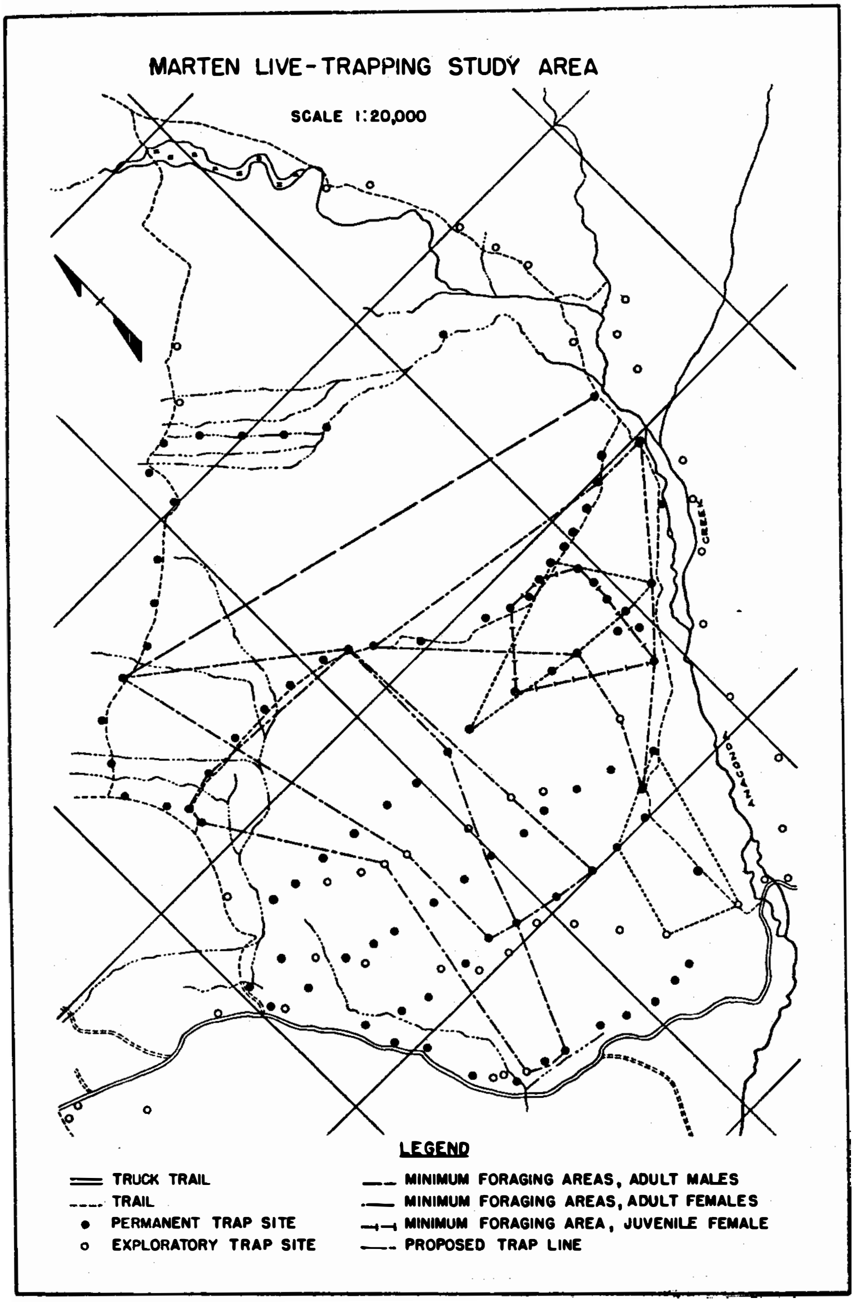

MARTEN LIVE-TRAPPING STUDY AREA
SCALE 1:20,000
CREEK
ANACONDA
LEGEND
TRUCK TRAIL
TRAIL
PERMANENT TRAP SITE
EXPLORATORY TRAP SITE
MINIMUM FORAGING AREAS, ADULT MALES
MINIMUM FORAGING AREAS, ADULT FEMALES
MINIMUM FORAGING AREA, JUVENILE FEMALE
PROPOSED TRAP LINE

FIGURE 1.

known-age material, techniques can be developed to distinguish a yearling class. At this time it seems safe to state only that juveniles may be separated from older classes with confidence until October.

TRAPPING SUCCESS

Using the trapping methods described, 223 captures of 53 marten were obtained from 1,912 trap units. Twenty-seven individuals or 51 per cent of the total were recaptured. Although the number of animals handled in this study was relatively small, it is believed that these 53 marten include almost all the residents and most of the transients which range through the area. The average effort required to capture one marten was approximately nine trap units. This compares with an average of 49 trap units in Ontario (de Vos, 1952) and 35 in Washington (de Vos and Guenther, 1952). As many as eight individuals were captured from 24 trap units in one day. Although marten on the study area may have become somewhat conditioned to the traps, this was evidently not a major factor in this trapping success, for trapping activities outside the Park in an untrapped area netted five individuals from twelve traps in the first night of operation. Three more marten were captured from nine traps on the same three and one-half mile line the second night.

Trap mortality consisted of one juvenile female found dead in the trap on September 8, 1953. Autopsy by the Fur Animal Disease Research Laboratory, Pullman, Washintgon, showed that the marten probably died of starvation with an accompanying anemia. A moderately large number of tape worms, not identified, were present in the small intestine. This marten had been captured for four consecutive days previous to the date of death. Weights of this animal ranged from 600 to 675 grams and averaged 633 grams, almost the same as the mean of 20 adult female weights. This raises a question as to population condition.

WEIGHTS

Twenty weights of adult females ranged from 550 to 775 grams, averaging 635 grams. Records of 69 weights from adult males varied from 725 to 1,250 grams, averaging 1,006 grams. On this basis, adult males averaged 59 per cent larger than adult females. Comparative figures from the literature are 55 per cent in Ontario (de Vos, 1952) and 12 per cent for *Martes martes* in Finland (Lampio, 1951). Although information from some months is not sufficiently complete, the records obtained provide an indication of seasonal weight variations. In September, the mean weight for adult males was 1,050 grams; three months later in December, the mean weight had dropped 200

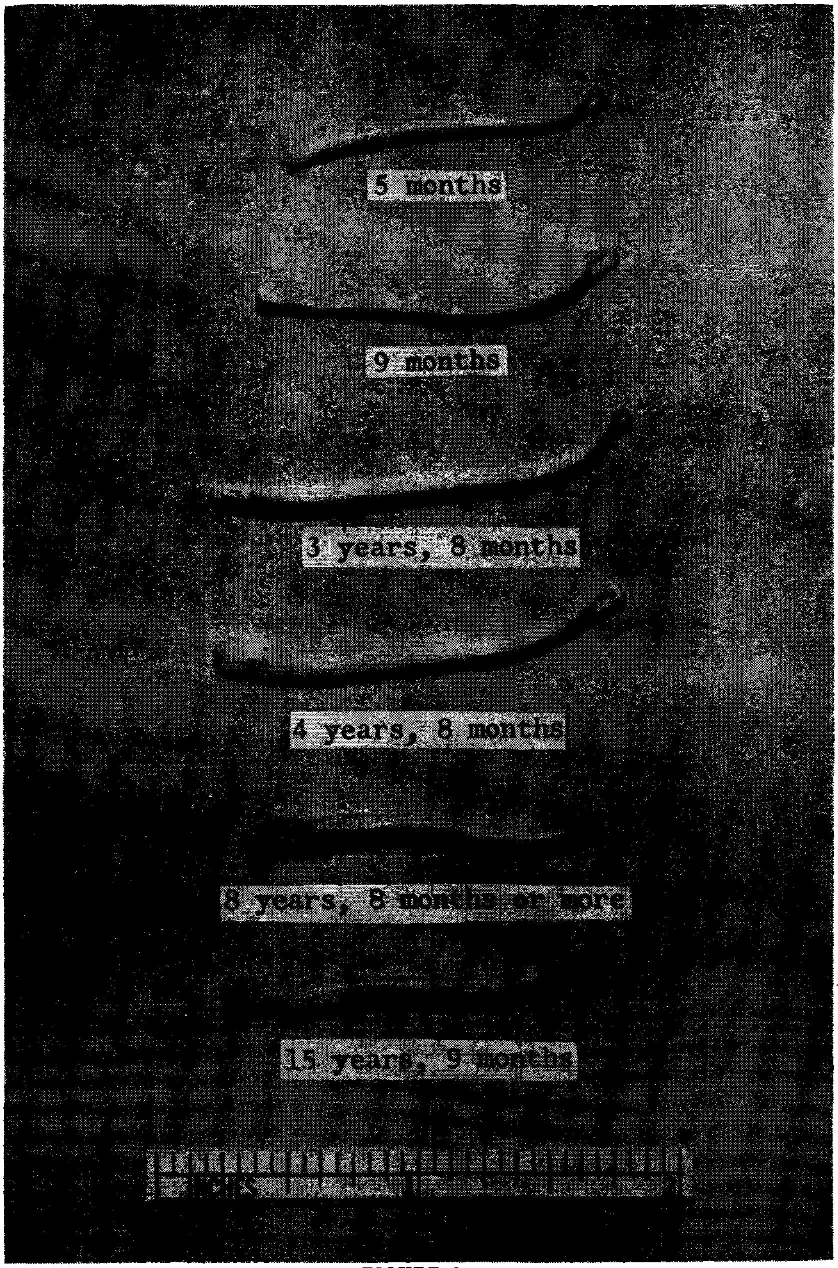


FIGURE 2.
Bacula of Known-Age Marten

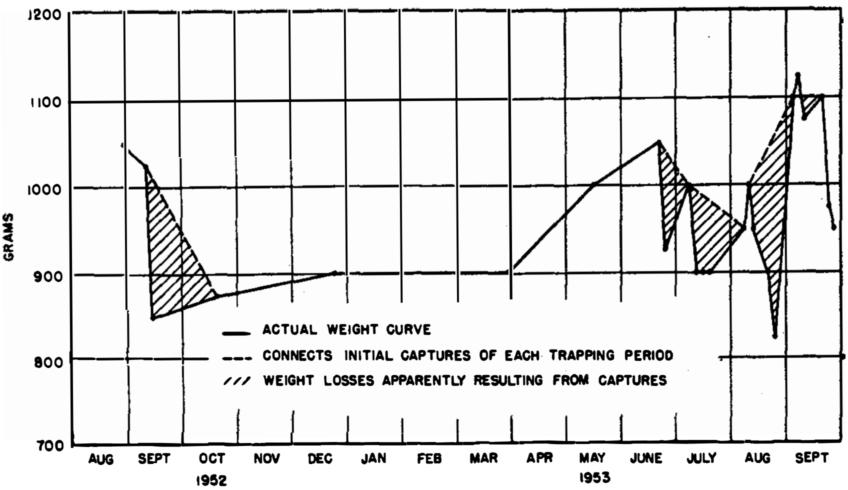
grams to 850. Limited weight records from females were of doubtful significance in this respect.

Weight loss sometimes occurred after capture on successive days. One adult male lost as much as 175 grams in one day (Figure 3). A similar pattern was evinced by juveniles, even during the period of growth. A juvenile male lost 200 grams during a two-week period of frequent captures. Losses were usually recovered after a few days cessation of trapping.

AGE AND SEX RATIO

Sixteen marten—9 males and 7 females—were tagged as juveniles. Thirty-six—21 males and 15 females—were yearlings or older. One marten escaped before determination of sex was made.

Sex ratios of large samples of marten taken by trappers have varied from 150 to 180 males per 100 females (Twining and Hensley, 1947; Yeager, 1950; de Vos, 1952; Reynolds, 1953a). In the present study a somewhat lower ratio of 135 males to 100 females (30:22) was obtained. Information collected by Yeager (1950) from 19 marten ranchers indicated a 100:100 sex ratio for kits. In view of this fact, it is of special interest that those animals believed to be resident on the study area were present in a 100:100 (5:5) sex ratio. The resident status of these animals was indicated by the fact that they were each captured throughout the period of study; and that the total of 106 captures for these animals provided the bulk of the 145 captures of adult animals.



WEIGHTS OF AN ADULT MALE MARTEN
FIGURE 3.

MOVEMENTS

Capture records from the ten adult marten believed to be residents show that a foraging area must be occupied for a considerable period by some individuals. Further evidence of established foraging areas is provided by investigations conducted in Washington (Guenther, 1948, 1949; Newby, 1951) where a male was captured two years later in the area of its initial capture and a female three years later.

As indicated earlier, a true grid system could not be used; therefore, minimum foraging areas were simply delimited by lines connecting the outside points of capture (Figure 1). Planimetered areas are presented in Table 1 for those marten on which the greatest amount of significant information has been obtained. Continued study and experimentation with trap spacing may extend these foraging areas; therefore, it is emphasized that these data are presented not as absolute values but rather to demonstrate a differential in the size of male and female foraging areas. Yeager (1950) pointed out that the wide foraging habits of the male most logically explained why more males than females were taken by commercial trapping. To our knowledge, quantitative evidence of this differential has not previously been established. The data in Table 1 do, however, substantiate this theory. The mean of minimum foraging areas for the males was approximately four times that of the females. Further indication of this difference in range is that distances between the most widely separated captures of the animals in Table 1 averaged 1.6 miles for males and 0.7 miles for females. In addition, all males captured more than once had a mean frequency of recapture of 9.2 times whereas the comparable figure for females was 4.4. This discrepancy in mean frequency of recapture may also be partially due to trap spacing improperly adjusted to the size of the female foraging area and to differential trappability. Experimentation with trap spacing may increase our understanding of this situation.

Captures on successive days at various times throughout the year provided records of 27 minimum daily movements of one adult male

TABLE 1. MINIMUM FORAGING AREAS

	MALES			FEMALES		
	Area (Sq. Mi.)	No. Captures	Period (Days)	Area (Sq. Mi.)	No. Captures	Period (Days)
	0.40	48	393	0.12	11	372
	0.61	8	334	0.13	5	118
	0.68	10	365	0.11[1]	13	56
Mean	0.56	22	365	0.12	9.7	182

[1]Area occupied by a juvenile female from July 14 through September 8, 1953.

marten. These movements ranged from 0.1 mile to 1.3 miles with a mean value of 0.5 mile.

Continued investigation will lead to the accumulation of more information on all the points discussed. Emphasis will also be placed on the study of other factors which may influence population dynamics. When population densities for the area have been established, it is believed that such information will make possible development of standardized methods for the determination of population levels. This is essential to proper management of marten on a statewide basis.

SUMMARY

Progress is reported for a marten live-trapping study conducted in Glacier National Park. Methods used in trapping, handling, marking, and age and sex determination are described. Data on trapping success and trap mortality are presented and evaluated. Weights are analyzed with reference to disparity of the sexes, seasonal variation and frequency of capture. Age composition of the captured animals is given by two classes—juveniles and yearlings or older. The preponderance of males in captures in the present study is compared with similar information from the literature. Data which imply an even sex ratio in resident animals are presented. Evidence of well-established foraging areas is pointed out. Apparent differences in range correlated with sex are indicated by greater minimum foraging areas and frequency of recapture of males. Minimum daily movements of an adult male marten are calculated from captures on successive days at various times throughout the year. Although it is not the purpose of this report to present definite conclusions, these preliminary findings illustrate the value of a long-range investigation of marten ecology based on live-trapping.

ACKNOWLEDGMENTS

Appreciation is expressed to the National Park Service for permission to conduct the study under the collaboratorship of Dr. Philip Wright, and for the use of their housing and communications facilities; to Dr. Philip Wright, Montana State University, and Dr. John Craighead, Montana Cooperative Wildlife Research Unit, for valuable advice and assistance; to Charles Crunden, student assistant, for aid during the summer of 1952; and to Lowell Adams, U. S. Fish and Wildlife Service, for loan of live traps. Financial support was provided by Pittman-Robertson Project W-49-R and the Montana Cooperative Wildlife Research Unit.

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DISCUSSION

MR. NEWBY: I wish I could say more about our management program than I am able to. At present there is no really organized management program. It has been a haphazard system opening the season at intermittent intervals and various pressures were brought to bear, I think. I hope, as the result of research accumulating that we will be able to establish some control system of management to place the cropping of this fur bearer on a state yield basis. But to date, that has been a very erratic thing.

MR. ARCHIE MOSSMAN (University of Wisconsin, Madison Wisconsin): I was wondering if you have any ideas on what causes the strange sex ratio in marten? I understand the same thing occurs in monkeys.

MR. NEWBY: What do you mean by the strange ratio?

MR. MOSSMAN: Such a preponderance of males.

MR. NEWBY: Well, I attempted to explain that in the paper on the basis of the wider foraging habits of the male. That seems to be the most logical explanation there, as pointed out by Mr. Yeager in his paper in 1950.

Now, we have quantitative evidence of this differential in foraging areas and I think if you consider what this difference might mean, it seems reasonable that just through this wider ranging, the male would have greater opportunity to be caught by commercial trappers, whereas the female with more limited foraging area would have less chance.

MR. CARPENTER (New Hampshire): You mentioned fisher and marten. What I would like to know is, is there a conflict between fisher and marten? Do you find fisher in your marten country?

MR. NEWBY: We have no authenticated records of fisher in Montana. I mentioned fisher because I quoted that statement I made verbatim from Dr. de Vos' paper.

MR. CARPENTER: I might add, in New Hampshire we used to have both marten and fisher. Then, they started trapping in the late 1920's. Since then, the fisher population has increased nicely, but the marten population has practically disappeared. That is why I wondered if there was a conflict between them?

MR. NEWBY: I am afraid I can't answer that.

MR. HORACE F. QUICK (University of Maine, Orono, Maine): I would like to make a comparison of population in northern British Columbia with those in Maine. In northern British Columbia, the martens far exceeded the fisher in population level, whereas in Maine now, we have very few marten, but I think, a dense population of fisher. There seems to be an inverse ratio. I have no explanation.

BEAVER MANAGEMENT PROBLEMS ON WESTERN PUBLIC LANDS

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It is widely recognized that beavers have increased in numbers and distribution during the last three decades (Dept. Agr., 1939; Dept. Int., 1940-46, inc.; Ashbrook, 1947-1953, inc.). This resurgence in the beaver is attributed mainly to protection from trapping and improvement in food conditions following lumbering and fire. It is inevitable that countrywide increase and spread of a mammal so intimately associated with the land, so influential on animal and plant life, so beneficial or destructive to man and wildlife, and so fluctuating in economic value *per se*, should create management problems of great importance.

On public lands in the West, beavers are harvested in various ways —licensed public trapping in Oregon; by permit and by state trappers in the Dakotas; on registered traplines in Idaho and British Columbia; and solely by state trappers, as in Colorado. Harvest, varying widely in success and degree of control, constitutes, with protection, the principal beaver management efforts in the West. This paper, therefore, will consider some of the problems that develop on public lands when the harvest is restricted largely to private property. In Colorado, these problems have grown out of statutes limiting beaver trapping to state employees on a complaint basis, with consequent neglect of the species on public lands. There are variations of this problem in most, if not all, of the western states.

The writers cannot present here a complete analysis of beaver management practices and needs in the West. Rather, they hope to call

[1]The Colorado A and M College, the Colorado Game and Fish Department, the Wildlife Management Institute, and the Fish and Wildlife Service, Department of the Interior, cooperating.

attention to trends and to some special problems, in the belief that the states, individually, are best equipped to meet the contingencies involved.

Finally, we feel that there is much to be learned about the ecology of the beaver over the wide range of habitats on which it occurs. We believe that intensive management, recently suggested by Patric and Webb (1953), can be instituted effectively only after the animal's varying role has been determined in such fields as meadow formation and destruction, waterflow and stream regulation, erosion and siltation, plant succession, and livestock and wildlife relationships. We urge that such ecological studies be instigated throughout the beaver's range.

TREND IN BEAVER POPULATIONS

A concrete grasp of the trend in beaver populations since 1934 may be obtained from the data presented in Table 1, which indicates the steady increase that has characterized both the annual catch and the number of states with beaver-trapping seasons.

Increase in western beaver populations was clearly pointed out a decade ago by Wire and Hatch (1943), who stated that, "Today beaver are overflowing their homes in many western streams." That the increase pointed out by there writers has been progressive in the western states since 1934 is indicated by annual harvest data given in Table 2.

Despite some lack of comparability in data given in Table 2, it is clear that during the last 20 years beaver populations, as reflected by the annual catch, have gone steadily upward. The decline in 1952 probably reflects the very low prices of beaver pelts rather than a reduction in populations.

The low in beaver numbers in the United States apparently came during the 1890's (Seton 1926, p. 449) when, "In 1891, the American

TABLE 1. NUMBER OF STATES WITH OFFICIAL BEAVER-TRAPPING SEASONS AND THE TOTAL BEAVER CATCH, 1934-1952[1]

Year	No. States	Total Catch	Year	No. States	Total Catch
1934	6	11.973	1944	21	73,974
1935	8	16.638	1945	18	78,915
1936	10	19.479	1946	18	98,817
1937	11	33,059	1947	18	69,021
1938	14	32.506	1948	25	80.610
1939	13	41.913	1949	23	72.074
1940	13	38.308	1950	28	107.455
1941	18	76,982	1951	31	146.568
1942	17	66.375	1952	32	130,998
1943	17	72,585			

[1]Compiled from references cited in first paragraph, and from correspondence with individuals listed under Acknowledgments.

TABLE 2. BEAVERS HARVESTED EACH FIFTH YEAR IN THE ELEVEN WESTERN STATES SINCE 1933 AND IN 1952

State	Catch for the year indicated 1934	1939	1944	1949	1952
Arizona	*	*	368	807	217
California	*	*	*	1,511[3]	1,642
Colorado	*	*	8,849	8,992	8,612
Idaho	222	702	7,000	5,917	7,694
Montana	5,649[1]	6,748	11,855	10,068[3]	10,000
Nevada	*	*	*	1,689	995
New Mexico	163	867[2]	1,430	1,200	800
Oregon	*	*	*	15,257[4]	8,005
Utah	374[1]	600	1,216	2,314	3,514
Washington	1,603[5]	2,539[5]	4,007	5,492	8,704
Wyoming	1,913	6,175	7,145	6,575	7,138
Total	9,924	17,631	41,870	59,822	57,321

*Season closed; complaint trapping permitted in some states.
[1]Fiscal year 1935.
[2]Fiscal year 1938.
[3]Trapping season of 1949-50.
[4]Trapping season of 1950-51.
[5]Trapping season of 1934-35 and 1939-40, respectively.

supply had dwindled to 11,693 (pelts), and the Hudson's Bay Company's was 57 260. . .'' Seton indicated (p. 450) that ". . .perhaps 1900 was the blackest year of all.'' The build-up, in the western states as in other parts of the country, likely began, therefore, in the early years of the twentieth century.

It is this steady growth in numbers, progressive perhaps since 1910, that has brought about present problems of beaver management.

COLORADO BEAVER BUILD-UP

Prior to 1937 beavers were trapped in Colorado under a permit system restricted largely to use on private land. In 1937 all permits were revoked by the Game and Fish Commission, and control of nuisance beavers was entrusted to five salaried trappers and about a dozen others who retained one-half of the pelts taken as compensation. With the enactment of the Beaver Control Act of 1941, harvest remained restricted to state trappers and largely for the relief of damage to private property. Beavers on public land, protected until 1937, were neglected after this date, except for poaching in some localities.

Under provisions of the 1941 law[2], landowners receive one-half of the sale value of pelts trapped on their holdings, and the Game and Fish Department retains the other half. All proceeds from beaver pelts taken on public lands go to the state. In all operations, control as well as harvest, the costs of trapping, pelting, and selling are borne

[2]The Colorado Game and Fish Department, aware of the shortcomings of this statute, attempted in 1953, but without success, to effect a Legislative amendment in the interest of better management of beavers on private as well as on public land.

by the Department either from its share of the returns, or from other Game Department funds when costs exceed returns. Since 1941, about 75 per cent of the total catch has been on privately owned land.

As the inevitable result of beaver harvest restricted primarily to private holdings, and in an age of negligible predation, beavers on the national forests and other public lands increased year after year. Steadily improved law enforcement, and declining prices for beaver pelts after about 1947, reduced poaching to a low volume. Thus, beaver breeding stock, particularly on inaccessible mountain range, grew until, along some streams, the habitat was destroyed and the animals forced to emigrate. Evidence of extreme population pressure was, and still is, indicated by the occurrence of active beaver colonies on numberless headwater rills, the prompt repopulation of trapped range bordering or near public land, and the impending exhaustion of aspen and willow along many inhabited streams. Further evidence is supplied by the cutting of pine and spruce trees, and the extensive use of sod in dam and lodge construction.

The writers are not in position to give densities of past or present Colorado beaver populations. They have good evidence of 60 animals per stream mile along Chavez Creek (detailed elsewhere in this paper), at an elevation of about 10,000 feet. Counts of active ponds and lodges in 1953 indicated populations of 20 to 50 beavers per stream mile on Two-bit, Stewart, Nutras, Los Pinos, and other high-country streams. Reconnaissance indicates that many other mountain streams in Colorado support similar populations (Figure 1).

INFLUENCE OF FUR PRICES

The economic value of beavers is most commonly associated with the price of pelts. But, as Table 3 shows, prices fluctuate greatly, and on this basis alone, beaver trapping may be profitable one year and unprofitable the next. With prices averaging $20 per pelt, there is incentive for trapping in areas that are reasonably accessible; but if current low prices continue, the management of beavers on the basis of trapping economy alone is precarious and highly uncertain. Yet, a fairly regular harvest is essential if beaver populations are to be maintained at sustained-yield levels.

The contingencies of price, therefore, require that other measures of the beaver's value—even though they be less tangible—be employed. Beavers are held in high esteem by some interests, and despised by others; and the wildlife administrator at times finds it impossible to satisfy all. Under such conditions, a knowledge of the beaver's *net* worth, ecologically as well as economically, becomes of inestimable

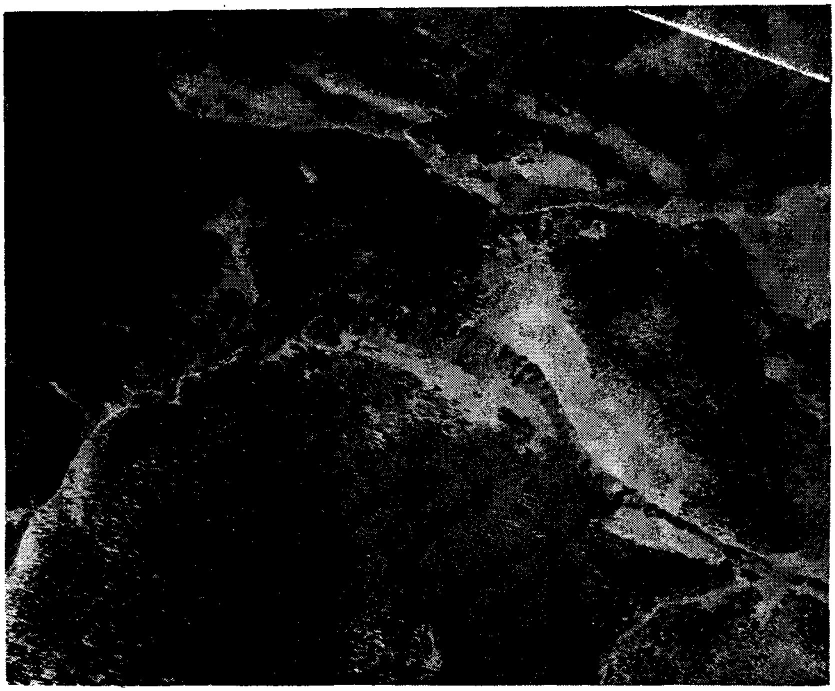

Figure 1. Aerial photograph of section of Los Pinos Creek, Gunnison National Forest, 1952, showing series of beaver dams and proximity of beaver activity to adjacent range and forest stands. Photo by U. S. Forest Service.

TABLE 3. TREND IN BEAVER PELT PRICES, 1941-1953

	Colorado		Maine[3]		North Dakota[3]		Wyoming		Manitoba[3]	
Year	No. of Pelts	Average Price	No. of Pelts	Average Price	No. of Pelts	Average Price	No. of Pelts	Average Price	No. of Pelts	Average Price
1941	4,169[1]	$17.46					10,946	$21.22		
1942	13,040	20.26					7.738	17.03		
1943	9,184	24.84					7,164	24.22		
1944	8,849	26.38			1,571	$28.14	7,145	24.63		
1945	7,036	29.22	3,506	$30.00	1,588	26.52	8,510	25.09	5.399	$39.00
1946	8,777	25.22	4,656	55.00	2.029	36.72	10,761	37.47	9.057	47.00
1947	8,722	23.78	4,661	40.00	1,885	17.38	8,718	16.77	7,878	30.00
1948	7,360	19.75	5,314	38.00	1,206	21.95	8,918	37.16	12.443	34.00
1949	8,992	12.11	6,113	25.00	1,172	15.39	5,895	[4]	14,099	22.00
1950	8,520	11.05	5.465	21.00	1,656	10.90	5,345	[4]	16,102	23.00
1951	9,164	12.88	5,411	21.00	2,102	12.40	11,623	10.86	18,400	23.00
1952	8.612	9.19	6,783	18.00	2.536	7.05	6,753	[4]	27,875	16.00
1953	5,564[1]	8.77	5,942	14.00	6,755	5.85	550[1]	13.28	23,436	14.11

[1]Incomplete.
[2]Hodgdon and Hunt (1953).
[3]Data given for trapping seasons, i.e. 1944 = 1943-44, etc. North Dakota data from Hargraves (1950, 1951); Manitoba: Dept. of Mines and Nat. Res., Winnipeg (1946-1952).
[4]Held, except for culls and small lots, because of low prices; incomplete sales in 1951 and 1953. Grasse and Putnam (1950) and personal communication.

value. Benefits to fishing, for example, appear to justify substantial subsidization of the beaver program at times when trapping is unprofitable. In any sound appraisal of the animal's net worth, reasonable stability in beaver populations becomes the crux of management, for those values which are positive when sustained yield is attained may, and indeed usually do, become negative without control.

Thus, as a result of many observations, we have been impressed with the real values of stabilized beaver colonies (Figure 2) and, conversely, the serious consequences of beaver-pond abandoment. These are considered in relation to other values and land-uses under the five headings that follow.

LAND-USE FACTORS IN BEAVER MANAGEMENT

Water. It is generally accepted that, in the development of the West, water for irrigation, domestic use, industry, and power is the major limiting factor. Importance of water and watersheds to the economy and welfare of the nation was recognized more than 50 years ago in legislation authorizing establishment of the national forests which, in the 11 western states, now comprise 137 million acres. Quantity, quality, and rate of streamflow are of primary concern to the administrators of these watersheds.

Much has been said in favor of beavers on mountain watersheds. The popular conception is that their dams hold back floodwaters and sediment, and that streamflow is more regular if not greater in total amount. They have been credited with creating the meadow lands of many valleys (Ives, 1942). Scheffer (1941) pointed to the importance of watershed influences by his statement: "In the present stage of land use in the Pacific Northwest, and for some years to come, to manage the beaver as a producer of fur is less important than to use it as a soil and water engineer." Little has been said about the damaging effect of unmanaged beavers on the watershed.

Runoff from snowmelt at the higher altitudes, and from occasional rainstorms of high intensity at all elevations, result in wide fluctuations in mountain streamflow. Peak flows that exceed the late summer normal by 100 times, or more, have been recorded (Rocky Mountain Forest and Range Experiment Station, unpublished). This condition, together with relatively steep stream gradients, accentuates the problem of channel erosion. The natural vegetation of well-sodded or willow-covered stream bottoms normally serves this purpose fairly well, but flooding by beavers kills or greatly alters the native vegetation, at times leaving only the dams to stabilize the stream course. The beaver has been given high rating as an engineer (Scheffer, 1938), but his structures require nearly constant maintenance if they are to withstand the forces of high water. Obviously, the dams can be kept in repair only so long as the colony remains active.

The writers have observed numerous areas in which unharvested beavers have so depleted their food supplies as to result in abandonment of dams. On Chavez Creek in the Gunnison National Forest,

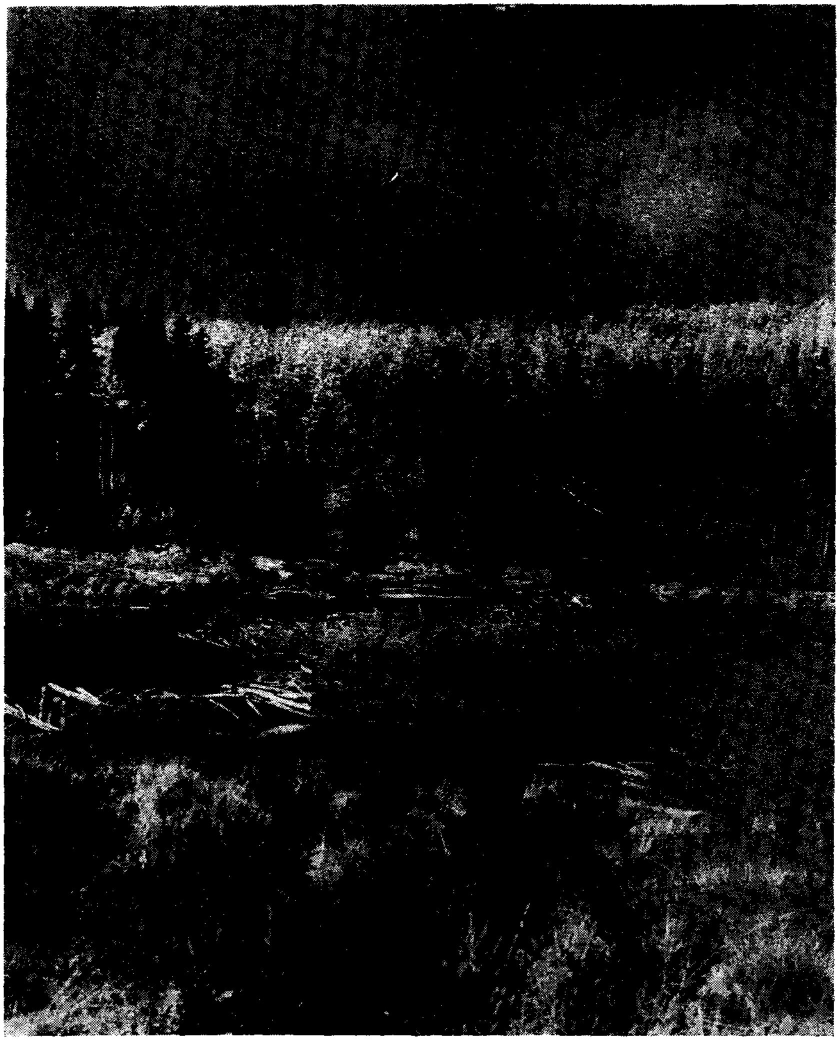

Figure 2. On small, high-country streams relative stability in beaver colonoies can be assumed from the presence of food, especially of aspen reproduction in graduated sizes in older beaver cuttings. This colony, on the headwaters of Los Pinos Creek, Colorado, shows these characteristics.

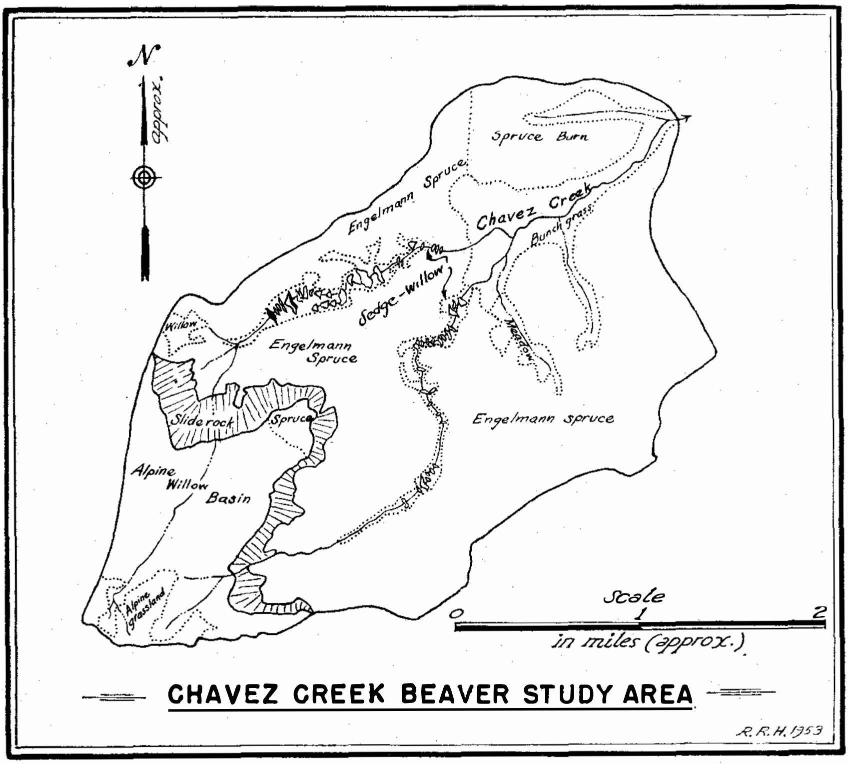

Figure 3. Map of a Chavez Creek drainage, Gunnison National Forest, south-central Colorado, as drawn from aerial photographs scaled to three inches per mile.

south-central Colorado, beavers occupied two sedge-willow meadows, (Figure 3). One valley, definitely the result of past glaciation, falls gradually on a grade of 3 to 4 per cent; the other is very narrow and has an average fall of 10 to 15 per cent. Lacking aspen, the dams were constructed of sod and earth excavated from the pond sites, (Figure 4). To obtain this material, the beavers had to "scalp" the vegetative cover and soil to an average depth of perhaps one foot over 80 to 95 per cent of the area flooded. More than 90 per cent of the material in such dams consisted of sod and soil, and an indication of the great volume moved is given by our measurement of 933 cubic yards of settled material in 12 dams and 9 accompanying lodge structures.

Through flooding and consumption as forage, the supply of willows was exhausted, and by 1939 beavers were no longer active in the area. All of the abandoned dams in the narrow valley, and nearly all of those in the glaciated valley, have broken. Stream channels have cut down to, or below, the levels estabished prior to the time of beaver activity. Pond sites, instead of supporting a thick, erosion-resistant sedge mat, were reduced to bare soil which, in 1952, had become only partially revegetated. The time required to reach the sedge-willow

Figure 4. Abandoned beaver dams on Chevez Creek, Colo¨ado, constructed almost entirely of soil. Lodges on this creek were likewise of soil construction. Such utility of sod and soil follows exhaustion of wood building materials. Potential meadow land is destroyed in the process.

climax stage has not been determined; and how long it may take to restore the former thickness of the sedge mat, after the climax species have been re-established, is problematical. Leisman (1953) indicates that organic matter accumulates at a rate of about a half-inch per year for the sedge-mat zone in Itasca State Park, Minnesota, but we know of no comparable estimates for the Rocky Mountain Region.

On Chavez Creek, considerable erosion has resulted from past beaver occupancy, and only a small portion of the displaced soil has been retained behind the broken dams. From the standpoint of watershed management, the net result of this period of beaver activity has been detrimental. Until a much heavier vegetative mantle has been restored the drainage will be subject to the hazards of continuing erosion.

Comparable results have been observed where aspen was available for dams. On portions of the Grand Mesa National Forest, Colorado, a combination of steep slopes and shale soils makes beaver management precarious. Beaver-made impoundments tend to saturate the ground, inducing land-slides. Tremendous gullies have resulted from the failure of baver dams on the unstable soils in this locality.

Some of the granitic soils of the Front Range in Colorado likewise are subject to severe erosion from excessive surface-water runoff. The failure of beaver dams has resulted in severe gulling, particularly in narrow valleys of steep gradient. Other factors—fires, logging, and livestock grazing—have of course contributed to the watershed problem here, as elsewhere, but in the present stage of management, the hazards involved suggest that where such streams are unoccupied by beavers they should be kept so.

In contrast with unfavorable conditions resulting from temporary occupancy by unmanaged beavers, dams of a permanent nature have been observed to accumulate, and more or less permanently retain, sediment and silt that would have gone on downstream had it not been for the impoundment.

The amount of water impounded by a single beaver dam of normal size is not impressive although Grasse and Putnam (1950) describe an exceptionally large dam 18 feet high that impounded 232 acre-feet in a body almost a mile circumference. However, the successive breakage of a series of 50 normal-size dams on a mile of stream—a number frequently found on long-occupied streams—can contribute to serious flood conditions. Such breakage and damage are far more likely to occur where sites have been abandoned than where beavers are present and currently maintaining their dams.

There are some indications that streams occupied by beavers tend to maintain late summer flows, whereas some apparently similar unoccupied streams fail to do so. It is the opinion of the authors that much study is needed before this observation is accepted as applicable throughout the West. Similarly, there is need for research to determine whether, and under what circumstances, beavers are responsible for increasing or decreasing the flow of streams and the supply of subsurface water. Some municipalities contend that beavers are a source of contamination, or reduce the potability of drinking water; others are favorable or indifferent to the presence of beavers on the watershed. All of these things point to the need for study, taking into account the highly variable conditions related to geology, hydrology, topography, soils, vegetation, animals, land-use, accessibility, and economics.

Wildlife. Western investigators (Cliff, 1936; Rasmussen, 1940; Tappe, 1942; Grasse and Putnam, 1950; Grasse, 1951) have concluded that beavers in the western mountain area are generally beneficial to other wildlife, especially trout. Values commonly attributed to beavers in this region include pooling and warming of water too cold for optimum trout environment; stabilization of stream-flow; creation of habitat suitable for waterfowl and aquatic fur animals; erosion control; and raising of the water table. Wire and Hatch (1943), among others, emphasized the damage caused by beavers on agricultural land, but agreed with various workers in regard to benefits to wildlife.

In Colorado, two graduate students, Robert L. Hoover and William H. Rutherford (unpublished), associated with the Colorado Cooperative Wildlife Research Unit, found that, except on some lakes, muskrats and waterfowl at high altitudes were confined almost exclusively on beaver-occupied streams.

In contrast to prominent eastern writers (Johnson, 1927; Salyer, 1935; Cook 1940; Bump and Cook, 1941; Bradt, 1947; Swank, 1949; Reid, 1952; and Hodgdon and Hunt, 1953), western workers, in general, have considered the beaver the key to good fishing on small, high-country streams. Most eastern authorities pointed out the beneficial early effects of beaver ponds, and their detrimental influences later. Virtually all investigators have been positive of the beaver's good offices in creating favorable habitat for waterfowl, aquatic fur animals, and other species found on beaver flowages.

The relationship between beavers and big game such as deer, elk, and moose is variable and not always obvious. However, in portions of Rocky Mountain National Park, wintering elk prevented the reproduction of aspen and willows to such a degree that some bottomlands formerly occupied by beavers became uninhabitable to them (Ratcliff, 1941). Cahalane (1943) described a similar situation in

Yellowstone National Park; and Murie (1951:256, 303) noted serious competition between beavers and big game, including moose, for these two food plants. The loss of aspen and willow by deer browsing has been detailed by Julander (1937) and others.

Studies conducted in Colorado during the last three years, and applicable in a limited way to other western states, partly confirm the findings of western investigators in regard to trout; and in regard to other wildlife, we are in agreement with both eastern and western students on many points, and in disagreement on some. We found, in summary, that benefits accrue to fish and wildlife so long as beaver colonies are active, but upon abandonment of dams the benefits are soon lost (Figure 5). The determining factor, therefore, in the beaver's true ecological position, including its hydrological and edaphic relationships, appears almost certainly to be that of maintaining populations within the carrying capacity of the range, achieved through systematic and controlled harvest.

An example is Chavez Creek in south-central Colorado. Prior to abandonment by beavers about 1939, this stream held a succession of beaver ponds, a total of 65 broken dams and empty basins being counted on a 1.25-mile stretch. During the period of beaver occupancy, trout were certainly abundant in the ponds and muskrats and nesting waterfowl must have occurred along the stream in numbers typical of high-country range. Use by big game can likewise be assumed since the locality is summer range for one of the most important deer and elk herds in Colorado.

During a week of observation in July, 1952, and in a brief coverage in 1953, no evidence of trout could be detected in the stream, which was then shallow, scoured, and eroded from one to several feet below the dry to muddy bottoms of the pond areas. There was no sign or observation of muskrats, minks, or ducks. Deer and elk use was restricted to the willow type upstream from the beaver-pond sites. Beaver cutting followed by sheep grazing had eliminated aspen from the streamsides of the lower, once-burned, portion of the valley.

Through the period of beaver build-up—1900 to 1935, and later in some states—protection and transplanting were the main management practices. However, as available range was filled, harvest became increasingly required as a means of preventing beavers from attaining overpopulations, with their attendant ills to the flora and fauna. Wire and Hatch (1943) discussed, by implication, the role of harvest in beaver management in the western states, although their viewpoint was necessarily attuned to the situation of the early 1940's. Since then, the "... overflows ..." cited by those writers have become

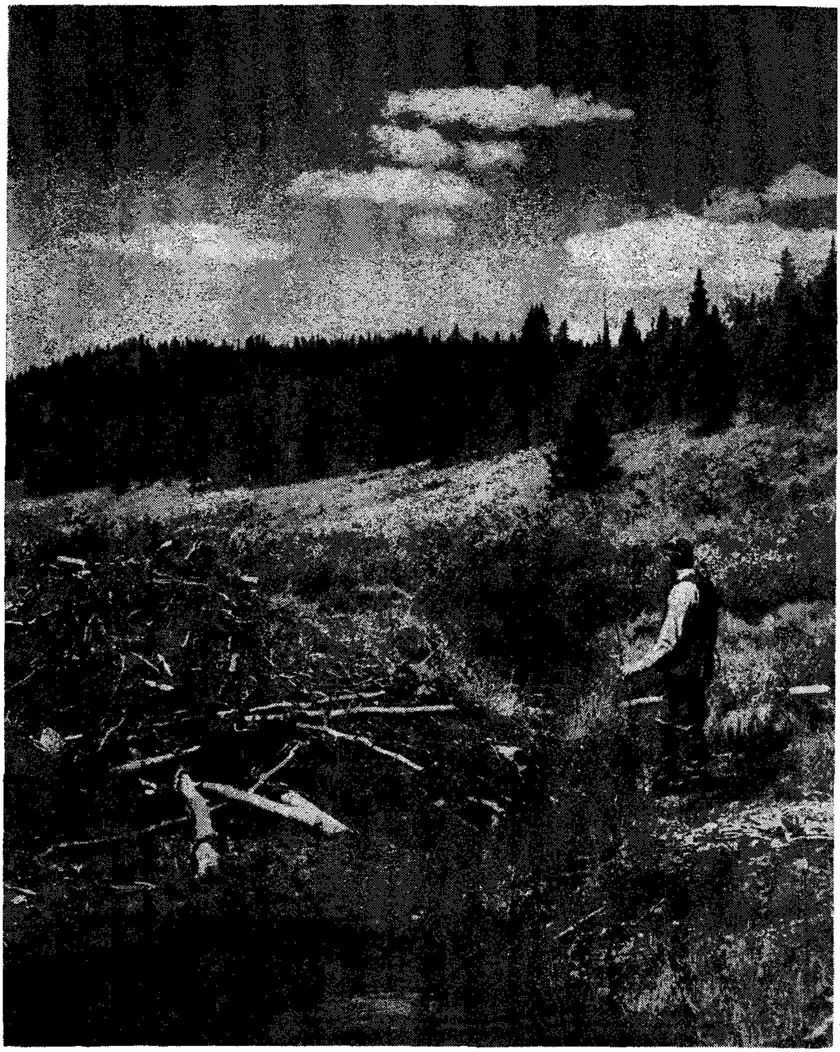

Figure 5. Following breaching of beaver dams, particularly after abandonment, lodges are often left on dry ground. In this instance, Stewart Creek, Colorado, a series of dams were broken in 1952 and left unrepaired since that time, resulting in lowering of the stream channel to about four feet below the present base of the lodge. Trout fishing was destroyed, waterfowl and aquatic fur-animal habitat was reduced, and the water table was appreciably lowered.

much more acute and widespread, and beavers now appear to be one of the species most in need of regulatory control.

Livestock. Beaver ponds are sometimes of value in range management as a source of water for livestock, but more often the flooding of meadows and the obstruction of free movement of livestock is looked upon with disfavor by stockmen. The raising of water tables adjacent to beaver ponds tends to increase forage production and may offset losses from flooding. Wire and Hatch (1943) mentioned the possibility of cattle being drowned in ponds or miring in wet pond margins.

In contrast with the usually minor effects of beavers upon livestock, sheep and cattle may, and often do, so modify sites once suitable for beavers that they are made permanently uninhabitable. In the absence of livestock, beaver-cut aspen and willow normally regenerate by sprouting. If there is an adequate initial food supply, and if beaver numbers are controlled, a colony may maintain itself for many years, or even permanently, sprouts of aspen and willow growing to usable size as the cutting of older stems progresses. However, cattle and sheep relish the young growth of both species, and unless livestock grazing is light, these principal foods of the beaver are killed. In such cases beaver occupancy can be only temporary. Where this condition prevails, and it is common on ranges used by livestock during the summer growing season (Scheffer, 1941), beaver management alone can do no more than extend the period of occupancy by reducing beaver populations so as to delay exhaustion of individual stems whose vulnerable parts extend above the reach of cattle and sheep. A permanent habitat for beavers can be assured only by reducing livestock use to the point where aspen and willow can reproduce. Depleted food supplies, therefore, cannot be attributed to a lack of beaver management in all cases.

Timber. In contrast with more level terrain in the East, western public lands are usually in regions of rough topography where individual beaver dams flood relatively small areas, and have minor effects upon stands of commercial timber. Possibly increased tree growth resulting from raised water tables would offset the relatively small loss of trees killed by flooding. Aspen, the major source of beaver food, is of little commercial importance in the Rocky Mountains at this time. However, from the standpoint of watershed management, and particularly for erosion control, aspen is the most important tree species in the region. Beaver management, therefore, becomes a real factor in the management of watersheds where this root-suckering species is needed to stabilize the soil.

The effect of lowered water tables on the vigor and growth of bordering spruce-fir stands, due to channel cutting on beaver-abandoned streams, has not been determined.

Recreation. Beavers, beaver cuttings, and beaver ponds are a source of enjoyment to many people. On the other hand, abandoned habitats, with broken dams and denuded pond-sites, are depressing to nearly everyone. Concern has been expressed that overpopulations of beavers in parks may result in elimination of this interesting animal from the native fauna; and the necessity of some trapping, even within National Parks, has been recognized. Public camp grounds, especially on flood-plain sites, are particularly vulnerable to beaver cutting and flooding.

Uninformed persons are likely to associate abandoned ponds with beaver trapping, whereas a *lack* of trapping may be the real cause. As with big game in many areas public sentiment based upon emotion rather than understanding may be a serious obstacle to beaver manegement. Education of the public to the need for sound laws is a major undertaking. To be effective, educational efforts must take into consideration the many indirect benefits of beaver management and should bring out clearly that management controls are essential in maintaining beavers on a permanent basis.

SUMMARY

1. Beavers have increased steadily in numbers during the last three or four decades, during which harvest in the United States grew from 11,973 pelts in 1934 to 130,998 in 1952. In the 11 western states comparable figures are 9,924 and 57,321, respectively. This dramatic increase in the beaver population has induced problems of great consequence in management.

2. On western public lands beavers are harvested (or sometimes not harvested at all) with varying degrees of success and control. This paper considers particularly the problems arising on public land when the harvest is geared mainly to control animals on private holdings.

3. On public lands in Colorado, beavers, except for protection and limited planting, have remained relatively unmanaged. Effective law enforcement and decline in pelt prices have reduced poaching to a small volume; negligible predation and fair to good range in earlier years favored increase; and as a result, the animals on some high Colorado ranges reached irruptive proportions as early as 1940. Most streams in the state are now fully stocked and many are gravely overpopulated; observed densities, even on small headwaters, being as high as 60 animals per stream mile.

4. Beaver pelts have fluctuated widely in value since 1940; the peak average of $30 or more for more western skins was attained in

1945 and 1946; and a near all-time low of $9 or less was paid in 1953. Relatively low prices have prevailed since about 1948. At the present economic level, average price of $20 or more per pelt is incentive for adequate harvest in the West, if regulations permit.

5. A present pelt prices, and in face of increasing damage, administrators must increasingly justify beaver management on other, and often less tangible, values, such as the species' effect on watersheds and wildlife and its relationships to recreation. A knowledge of the animal's *net* worth, ecologically as well as economically, thus becomes of great value in beaver-management programs.

6. In the management of western watershed lands, the beaver's place, often complex, is governed by population stability, attained by holding numbers to the carrying capacity of the range. Such stability, or sustained yield, is most practically achieved through systematic and controlled harvest.

7. Mountain streams are periodically subjected to high water which, with steep gradients and often narrow valleys, necessitate a good vegetative cover to prevent erosion. Beaver activity, if not regulated, results in loss of cover and subsequent soil displacement, particularly where dams are abandoned. The benefits of optimum beaver populations are thus lost on unmanaged range.

8. In partial contrast to other workers, the writers have found beavers beneficial to trout and water-frequenting game and fur animals on western public land *only* when numbers are kept within the range-carrying capacity, which is usually low on the small streams involved. Under sustained yield management beavers create, and usually maintain, environment suitable for trout, waterfowl, muskrats, minks and other aquatic and wetland forms. Without management these values are lost.

9. Livestock grazing often prevents regeneration of aspen and willow, thus reducing beaver occupancy to a temporary status. In not all cases, therefore, are beavers alone responsible for abandoned dams and resultant damage. Along many streams the foraging of beavers and livestock together has eliminated the food supply necessary for continued beaver habitation. Overbrowsing by big game animals may have the same effect.

10. Beavers flood relatively little timber on western public lands, due to the characteristic narrow, V-shaped valleys. Aspen is now of little commercial value in the Rocky Mountains. It is, however, the most important tree species in this region for erosion control, necessitating careful regulation of wildlife and livestock use to insure ample soil protection.

11. Recreationally, beavers rank high. There is danger of losing

this value on overpopulated streams due to the animal's tendency to "eat-out" and abandon its range, inducing the unattractive conditions described.

ACKNOWLEDGMENTS

In the preparation of this paper the writers have received much assistance from Mr. John D. Hart, assistant director of the Colorado Game and Fish Department, who supplied historical details and official records invaluable to our purposes. Director Thomas L. Kimball gave much encouragement through his broad interests in beaver administration; Federal Aid Coordinator Laurence E. Riordan and Superintendent of Fur Resources Dean Coleman contributed field observations and various details of control operations; and many other Department employees aided individually in this attempt to define beaver problems on western public land.

Dr. John L. Retzer, Soil Scientist, Rocky Mountain Forest and Range Experiment Station, Fort Collins, is credited with calling our attention to the soil and hydrological relationship of beavers on small mountain streams. U. S. Forest Service specialists from all western Regions provided information pertinent to the national forests; and personnel on the Gunnison National Forest in Colorado, where many of our personal observations were made, were very helpful.

The following State and Provincial officials graciously provided information or answered our questions: James E. Grasse of Wyoming; Robert F. Cooney and Fletcher E. Newby of Montana; J. Burton Lauckhart and O. L. Resner of Washington; H. R. Morgan and Edmund Hibbard of North Dakota; Joe B. Davidson and Lysle R. Pietsch of Illinois; John M. Hall of Arizona; Levon Lee of New Mexico; Roger M. Latham of Pennsylvania; William B. Barnes of Indiana; and G. W. Malaher and Alex J. Reeve of Manitoba. We gratefully acknowledge this assistance.

Finally, we wish to thank Professor J. V. K. Wagar of Colorado A and M College, Lloyd W. Swift and Merle A. Gee of the U. S. Forest Service, and Durward L. Allen, Frank G. Ashbrook, and Daniel L. Leedy of the U. S. Fish and Wildlife Service for reading and constructively criticizing the manuscript.

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DISCUSSION

MR. DAVID SHETTER (Michigan Department of Conservation, Lewiston, Michigan): I would like to ask if you are running into any conflicts with the trout interest in the management of beaver in Colorado? In Michigan, there has been for some time a minor controversy as to the effect of beaver on our trout.

MR. HILL: Our conditions are probably much different from yours in the Lake State areas. Our high streams are cold. They lack food; they lack pools, they are on steep grades normally, and the observations indicate that beavers more often improve the fishing.

Now, one thing I think we should bring out, we have not used Colorado examples to be critical of the management by the Game Department. The Department has made an effort to have legislation passed, which will permit management under the Commission form of legislation, but so far the legislature has not done that.

MR. JAMES H. DAHLEN (Wisconsin Conservation Department, Madison, Wisconsin): In the areas where your food supply has been almost completely exhausted, have you noticed any secondary preference for other species or any other crop?

MR. HILL: There is practically no other choice. The beaver, as a last resort, will work on ponderosa pine and range spruce. There is a question as to whether that will sustain them very long. But, besides the aspen and willow, there is very little food. There is a limited amount of birch, and there is very little choice.

POPULATION GROWTH AND GAME MANAGEMENT

ROBERT F. SCOTT

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What is "practical" game management? To my mind, management is practical only when it gets the best possible results under all circumstances. Producing wildlife in some ways is like milking a cow. A good practical farm hand with the right touch can get more out of the cow than a greenhorn. But no matter how refined this practical technique of milking becomes, it alone cannot go very far toward getting the highest possible milk production from the animal. A record production will represent the thorough and effective use of the principles and techniques of all the fundamental sciences relating to the cow—genetics, physiology, nutrition, and so on; and no doubt some of these would not seem very practical to the man on the faucet end of the beast. I sometimes wonder whether, in our enthusiasm for being "practical" in game management, we do not likewise slight some of the fundamental principles of biology that could be put to good use in getting the best results possible from our wildlife resources. In this discussion, I will deal with several of these fundamental principles and their relation to common problems of game management.

In the years since game management began to achieve the status of a profession, its pratice has become an art, based on a combination of several sciences. Of late, however, it is becoming increasingly evident that the one science most intimately involved is that of population dynamics—a relatively new concept in itself. As Hawley (1950) has suggested, variation in the numbers of animals is one of the most important means of adaptation to the environment, and changes in numbers, or changes in rate of increase or decrease are some of the most sensitive and occasionally most accessible indexes of ecological conditions. Game management is directly concerned with interpreting or manipulating changes in animal numbers, and the science of population dynamics is directly concerned with developing the principles and explaining the patterns according to which these changes occur. Therefore, the two must inevitably combine. The growing number of quantitative formulas appearing in the literature of game management in recent years is encouraging evidence that this trend is underway.

In this paper, I will discuss the one phase of population dynamics that involves principles of population growth; emphasizing a few basic concepts, and describing some of their applications to game management. It must be admitted that the classical principles of population growth are not always expressed in their pure or simple form in nature; and while some biologists (Thompson, 1942; Brody, 1945) attach considerable significance to the mathematically analagous growth patterns found in a variety of situation, others (Errington, 1951; Rounsefell & Everhart, 1953) tend to minimize their significance. From the standpoint of game management, however, I believe the theories do provide a valuable basis for integrating a number of important management principles that in recent years have been discussed, or in some cases hinted at, in a variety of terms. I hope this treatment will emphasize these concepts so that, as Graham (1952) has said in a similar situation, those elementary principles that are at the back of everyone's mind will, in their isolation, appear completely self-evident.

The discussion can best be introduced by these words of Aldo Leopold (1943, p. 5), "We now know that animal populations have behaviour patterns of which the individual animal is unaware, but which he nevertheless helps to execute. Thus the rabbit is unaware of cycles, but he is the vehicle for cycles. We cannot discern these behaviour patterns in the individual, or in short periods of time." Patterns and principles often go hand in hand, and it is thus of interest that ten years later a committee of the Wildlife Society (A. S. Leopold *et al.,* 1953), reporting on research needs, has pointed out that "in the long run it is the principles rather than the details which will form a sound foundation for management."

The nature of population phenomena are such that the theoretical or experimental approach has usually been the quickest to reveal underlying patterns and principles. Many of the basically significant discoveries and concepts of population dynamics have been developed and pursued in the rarified air of higher mathematics, or the sometimes esoteric ramifications of experimental biology. As a result, there seems to be an unfortunate and growing lag between the significant advances in knowledge of population phenomena, and their practical application in the field of game management. Our fellow workers in the older profession of fishery management have made greater use of certain principles of population dynamics, and indeed many of the principles have been developed in fisheries research. But then fishery people are not exposed to as many distractions from basic population phenomena as are game managers. They have been obliged to deal with such things as the impersonal mathematical history of an age class while we may have been attempting to explain to sportsmen why a certain deer died in the woods.

Game management also differs from much theoretical and experimental biology in that it has been exploring exactly what happens to individual animals, populations or environments. In contrast, laboratory experiments have often begun by recording patterns of effects, and expressing them mathematically, without knowing exactly what the causes were. The former has been isolating the mechanisms, the latter, the principles. In some cases mathematical computations alone have been transformed into biological theories which can be accepted as at least tentative principles of interest to game managers. However, if such theoretical or experimental conclusion are actually of importance as basic principles, then we should be able to describe and understand their significance, as principles, without delving into their mathematical development. This discussion proceeds on that assumption.

THE SIGMOID GROWTH CURVE

For centuries, men have implied that it is in the nature of living things to multiply their numbers. That this is a fact in a strict mathematical sense as well as a rhetorical one was impressed upon the world by the British clergyman, Malthus, toward the end of the 18th century. He pointed out that, in multiplying, the human population actually grows in a geometric progression; in other words, growth of the population tends to be exponential. This means that the amount of growth added at any given time is in proportion to the size of the population at that time; and the particular fraction represented by this proportional relationship is then the *relative rate of growth* of that population, usually expressed as a percentage. A common analogy is the accumulation of compound interest by a sum of money, and similar exponential progressions are found in many natural phenomena. The growth in weight of an individual organism during certain phases of its life is one of the more significant comparisons.

But this exponential growth is only part of the story. Thompson (1942, p. 144), reminds us "... how formidable a thing successive multiplication becomes. English law forbids the protracted accumulation of compound interest; and likewise nature deals after her own fashion with the case, and provides her automatic remedies ... multiply as they will, these ... populations have their limits. They reach the end of their tether, the pace slows down, and at last they increase no more. Their world is fully peopled, whether it be an island with its swarms of hummingbirds, a test-tube with its myriads of yeast cells, or a continent with its millions of mankind. Growth, whether of a population or an individual draws to its natural end; ...."

Soon after Malthus' time it became obvious that the course of growth in any population must be determined by the interplay of these two great forces—the one seeking to expand exponentially, the other inexorably curtailing and finally bringing growth to a halt. In later years Chapman (1928) formalized this relationship as the conflict of "biotic potential" *vs.* "environmental resistance," a concept that has since become a cornerstone of game management theory. However, as early as 1838, the Belgian demographer, Verhulst, sought to give mathematical shape to the same conclusions. He assumed that the initial growth of a population would indeed tend to be exponential—in proportion to its size at all times; but that in addition, as it increased in size and neared the ultimate limit beyond which it could not grow, a limiting and retarding effect would also be felt. This influence would be exerted proportionally, and in increasing severity as the population increased in size. He developed a differential equation to express this systematic relationship and showed it graphically as the classical "logistic" curve of population growth. This curve is S-shaped, or sigmoid; it is symmetrical; and it has fitted closely the actual recorded growth cycle of yeast populations, an autocatylytic chemical reaction, and numerous other growth phenomena. It is a cumulative summation curve depicting the change in size, with time, of a population growing according to Verhulst's "law"; or, more accurately, according to his assumptions. The curve ABC in Fig. 1 is typical of such sigmoid growth curves.

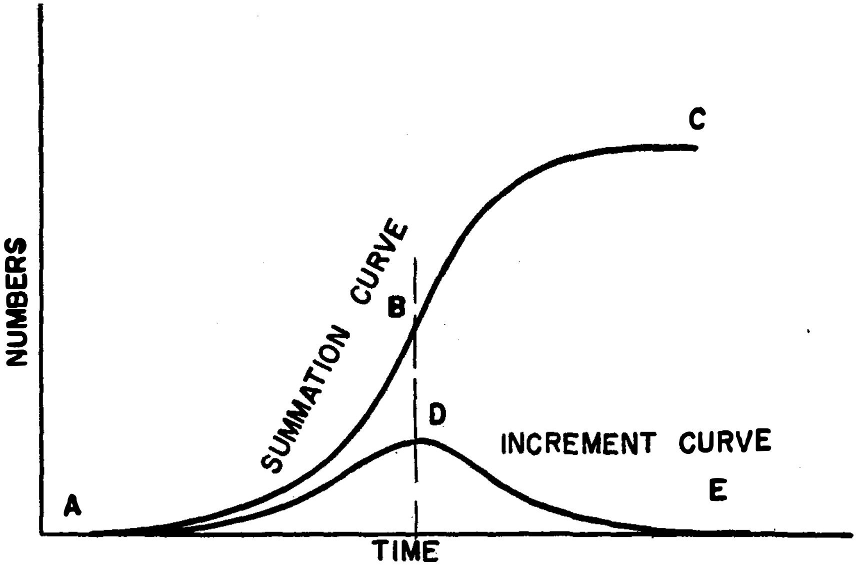

Figure 1. Summation curve and increment curve representing growth of a yeast population. (After Hjort *et al*, 1933)

Over 30 years ago, the American biometrician, Raymond Pearl, and his colleagues began working anew with population problems, seeking to perfect a more accurate mathematical representation of the "law" of population growth. Verhulst's formula was modified, deficiencies of his original logistic curve were explained, and new equations were developed to take into account the complexities of generalizing a mathematical description of the growth of a poputtion from start to finish. It became obvious that not all sigmoid growth curves were symmetrical, and a whole new family of skewed, S-shaped curves were, on occasion, used to describe the course of growth observed in various populations. The effort has always been to generalize a description of the growth pattern, but in doing so, Pearl and others have attempted to develop a single equation to fit the entire sequence from beginning to end, and inevitably it has become complex and often unsuccessful.

Brody (1945) has adopted a different approach; one which is simple, perhaps more reliable, and certainly easier to apply in problems of game management. He regards the growth curve as merely a combination of two characteristic patterns; one exponential growth, and the other exponential decline in the rate of growth. Both are akin to the mass action law of chemistry and physics, and both may be regarded as significant in themselves. He prefers to treat these constituent segments separately in his analysis of growth, and it will be advantageous to do the same in this discussion.

To summarize thus far; biologists have shown experimentally and expressed mathematically, that growth in a limited environment (and all growth has an ultimate limit) tends to proceed initially as an exponential progression, but that eventually limiting factors make themselves felt, growth gradually slows down, and finally approaches an end as the maximum upward limit is reached. The summation curve representing this course of events (Fig 1) is composed of a concave lower segment of increasing slope, and a convex upper segment of decreasing slope; the two joined at a ''point of inflection'' (Point B, Fig. 1) where the trend of the curve changes from acceleration to deceleration. The relative duration of the lower accelerating and upper decelerating phases varies in different circumstances, and the point of inflection may occur midway along the curve, or toward either end. These two segments of the curve will now be discussed individually, together with certain pertinent characteristics associated with each.

ACCELERATING PHASE

In the absence of inhibiting forces, a population of reproducing units, whether it be an assemblage of organisms or an assemblage of cells in an organism, will tend to produce new individuals in proportion to the number of reproducing units present. The *percentage* rate of growth will remain constant, and therefore the amount of new growth added at any given time will be in proportion to the amount of growth already made, or in other words, to the size of the population at that time. Though the relative percentage *rate* of growth remains constant, the *amount* of growth that is added grows larger all the while, because of the nature of proportions. Thus such a progression, when graphed on ordinary cross-section paper will be shown as as ascending curve of steadily increasing slope. It will represent a self-accelerating or expotential increase in the *amount* of growth, while the relative percentage *rate* of growth has remained constant.

As pointed out earlier, changes in numbers, or in rates of increase or decrease of animal populations are of considerable biological significance. The concave, ascending curve of accelerating growth is a familiar one in game management and it is often important to know whether the curve at hand represents a constant percentage rate of increase, or a rate which may itself be increasing or decreasing. The quickest way to discover the nature of the change is to plot the curve on a semi-logarithmic or ratio chart. If the rate of increase represented by the curve is constant, it will plot as a straight line. If the rate itself is increasing or decreasing, it will plot as a rising or falling departure from a straght line. Croxton and Crowden (1939) give an excellent discussion of these graphic methods.

There are several convenient ways of determining the constant rate of increase displayed by such a growing population. It may be read directly from the slope of the straight-line logarithmic plot, or the compound interest formula may be used as described by Kelker (1947). Or if only index figures, such as the number of animals per unit area, are available, the percenetage rate of increase may be calculated when the period of time required to double the population is known. However, when calculating over a period of years, care should be taken to distinguish between a truly constant rate of increase, and one which is only an average of two or more different, but constant, rates that may have been in effect during parts of the period.

Any constant rate of increase will produce an ascending curve which eventually approaches the vertical when plotted arithmetically. But it is the relative rate of increase which determines the rate of curvature, or the slope of the straight line when plotted on a semi-logarithmic chart. A typical example of such data is shown in Fig. 2. The growth of an introduced reindeer population on St. Paul Island has

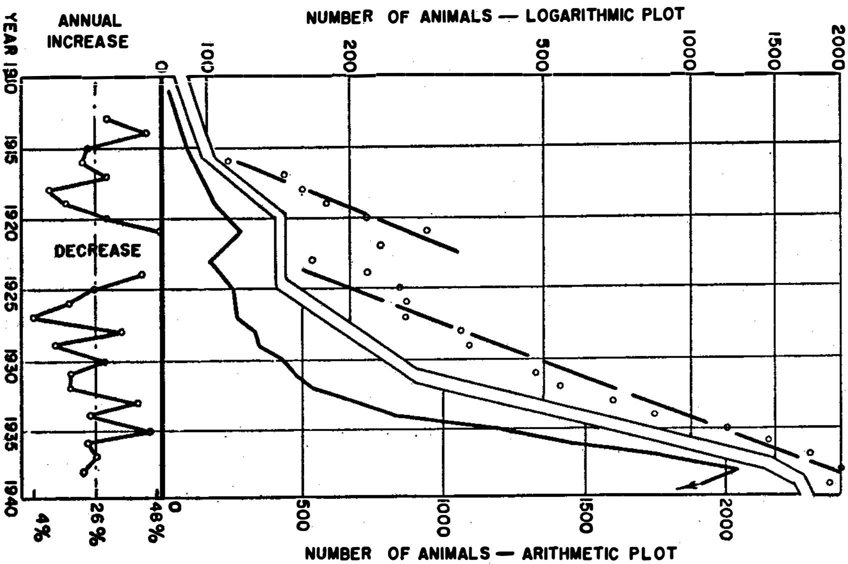

Figure 2. Population growth, and fluctuations of the annual rate of increase, in the St. Paul Island reindeer herd. (Data from Scheffer, 1951)

been recorded in a unique and valuable report by Scheffer (1951). Both arithmetic and logarithmic plottings of the population data are shown in the figure, together with calculated values for the percentage increase experienced each year. It will be seen that although the annual increase fluctuated markedly, from 4 per cent to 48 percent, averaging about 26 per cent, the general trend of population growth was little disturbed by the fluctuations. It is also possible to detect further subordinate trends of the rate of increase in the departure from the straight line logarithmic plot. However, the obvious tendency to produce a general trend despite constant variation and irregularity is one of the significant characteristics of growth patterns.

The rate of increase of any population during the accelerating phase of growth is mainly the product of the schedule of fertility and mortality characteristic of that population under the existing circumstances. Slight changes in the fertility and mortality rates will produce a corresponding change in the rate of increase. Thus a population whose growth is still accelerating at an uninhibited constant rate, may be realizing a rate of increase which is quite different from that of another population of the same species also experiencing uninhibited accelerating growth, but under different circumstances. This distinction between an unimpeded increase at a constant rate, and the relative value of the rate itself, is an important one, involving the meaning of the term "uninhibited" when applied to population growth. On the one hand, the fact that growth is accelerating at a constant rate indicates a certain stage in the dynamics of the population itself. On the other hand, the relative quantitative value of the constant rate is an expression of the fundamental adjustment of whatever species is involved, to the circumstances under which that particular population is growing. It is the distinction between merely the *fact* of a constant rate of increase, and the ***velocity*** at which it is proceeding. There may be racial characteristics involved, as well as characteristics of the local environment which will determine what the maximum rate can be under the particular circumstances. Thus in calculating growth potentials, or evaluating observed increases, it is desirable to deal with the "true intrinsic rate of increase" for the given species under the given circumstances, as described by Birch (1948). This "true" rate will reflect existing schedules of fertility and mortality and it will be more meaningful than a hypothetical and less realistic "biotic potential" which has little liklihood of being realized, even though the population may be experiencing "uninhibited growth." It is also significant to detect changes from one constant rate to another, or the presence of a long-term gradual change, either of which may be associated with the accelerating growth phase. These changes, themselves, will have important biological interpretations.

It is also important to realize that any growth is actually a function of the physically reproducing units in a population. Thus, although growth of an individual animal is often related to the total weight of an animal, it is actually a function only of the metabolizing tissue and is expressed in relation to the entire weight for lack of a better base. By the same token, growth in animal populations is a function of the physically reproducing female units, though it is commonly expressed in relation to size of the entire population. The situation might be compared to a chemical reaction, with the male segment of the population acting as a catalyst, so that when present in a sufficient minimum proportion (which will vary with the breeding habits of the species) the growth reaction occurs at a given rate within the female segment of the population. It is only when the growth is expressed as a percentage of the entire population that the number of males present (aside from the certain minimum) becomes significant. Even then, the significance is only a mathematical one, to the extent that the number of males affects the proportional relationship. In this sense, the existing sex ratio can have a great effect upon the apparent rate of increase when it is expressed in relation to the total population. The fewer the males, the higher will a given rate of production by females appear to be when related to the population as a whole.

Significance to management. What is an "irruption"? It seems almost unnecessary to point out the connection between accelerating growth patterns and the irruptions in game populations. Yet we very often see reference to populations which "grew slowly for a while, and then suddenly irrupted." Often too, there is speculation as to what caused the "sudden" irruption. A clearer appreciation of these phenomena may result when they are viewed in their simpler sense as merely the inevitable result of the continued growth of any population at a constant rate. Thus the published records of numerous irruption phenomena, such as that very complete one provided by Mohler *et al.* (1951), upon examination show clearly a constant rate of growth in operation. Under such circumstances, an appreciation of the exponential nature of growth can lead to a more exact preview of what is in store, than that which has been indicated by the tentative predictions of "trouble" often made somewhere along the line.

The particular rate at which any population grows will determine how quickly the curve will assume the slope finally recognized as irruptive, and this in turn will depend on local conditions as well as the characteristics of the species. Comparison of observed growth rates in various populations can often suggest a variety of significant biological conclusions, but the rate of increase recorded in any one year should not be accorded too much importance since it has been shown that considerable variation and irregularity can exist naturally without destroying a trend.

INFLECTION AND THE DECELERATING PHASE

The point of inflection, and the decelerating phase of the sigmoid growth curve are perhaps the portions of greatest significance in ecological problems. The accelerating phase poses no mystery; it represents what any population will do if given the opportunity. It is in the failure of a population to realize this continued exponential growth that we see the operation of limiting factors of concern to game managers.

In the classic logistic growth pattern described by the Verhulst-Pearl comprehensive equation, the limiting effect of the fixed maximum ceiling toward which growth is proceeding, is felt from the very beginning of the accelerating phase. This means that even as growth is accelerating, the rate is proportionally departing more and more from the inherent exponential tendency. Finally, the retarding influence overcomes the expansive drive, and beyond the point of inflection the rate of growth begins to decelerate and finally dwindles toward zero as the maximum limit is approached. This is typified by the segment BC of the summation curve in Fig. 1.

As Brody (1945) has pointed out, this fine mathematical balance is not always found in specific growth patterns, and the ways in which the growth patterns may diverge are often significant themselves. In natural populations of higher animals, especially, the original exponential tendency may be followed for considerable periods of time (see Fig. 2), though perhaps with occasional changes in the base rate. Eventually, however, there is a transition to the decelerating phase, and detection of this change is of great importance to game managers, as will be emphasized later.

Unfortunately, as Allee *et al.* (1949) have noted, it is difficult to find records for natural populations that are detailed enough to permit a systematic analysis of the growth pattern. This, of course, is one of the difficulties of game management; the task of obtaining quantitatively accurate population data is often nearly impossible because of the habits of the animals and the unavoidable deficiencies of the methods used. Important decisions must therefore be made on the basis of data which would never be acceptable in experimental biology. It can nevertheless be hoped that as quantitative population analysis is more widely used in game management, there will be a corresponding refinement in the gathering and reporting of the basic data. Careful design of sampling systems, and rigorous statistical evaluation of results will be the only satisfactory basis for assigning quantitative significance to the data obtained.

Examination of growth curves such as that given by Rasmussen (1941), or in some cases manipulation of data such as that given by Martin and Krefting (1953), suggest that in certain natural game populations the transition from exponential growth is first expressed by a change to linear growth. In other words, the number of animals added per unit time may tend to become constant, rather than increasing in proportion to population size. This may be significantly analagous to a similar pattern observed by Klem (1933) in growth of a yeast population under conditions comparable to an overcrowded range. Even following such a transition, exponential growth will occasionally be resumed if environmental conditions change for the better; and this then is analagous to the "new cultural epochs" of Pearl (1924) in the growth of human populations.

Under the simplified conditions of the classical growth pattern, however, a systematic deceleration will begin after the transition at the point of inflection. During this phase, the rate of growth declines, rather than remaining constant, and the decline is in proportion to the size of the growing population in relation to its maximum ultimate size. Brody expresses this phenomenon as merely a variation of the mass action law in a negative sense. Another way of saying it is that, even though the population is still growing, the amount of growth added is steadily becoming less, in direct proportion to the amount of remaining growth yet to be made to reach the ceiling level.

Thus, although the deceleration is a function of the value of the ultimate population ceiling level, it is at the same time a complementary function of population size. Hence, very significantly, it is also a function of density. The decelerating phase may therefore be expressed as a rate of increase which is inversely proportional to density, and we immediately are on familiar ground in the field of game management. From a mathematical viewpoint it is of interest that one expression of this relationship is given by another systematic exponential progression, but this time a negative, declining one. Such a curve will be strikingly similar to the relationship of population size and rate of increase expressed in the "recovery curve" of Errington (1945). Since the curve does have a mathematical expression, it should be possible to calculate and predict the maximum population size for any species exhibiting decelerating growth toward a *fixed* environmental limit.

Until now we have regarded the sigmoid growth curve in its usual setting with time as one of the coordinates. Time, however, is an indefinite frame of reference for many purposes. Its units may be expressed in days for one population and years for another, and as Brody reminds us, it has no real connection with the physiology of growth, but is an artifact of our own making. Thus to emphasize better the ecological implications of the growth curve, we can substitute *relative density* for time on the abscissa of the graph (Fig. 1), and visualize growth in its true status as a function of size or density. The point of inflection then becomes the expression of a "threshold" density value.

The emphasis upon identification of "limiting factors" in game management is in contrast to the mathematical treatment of population growth, wherein the limiting influence, as Slobodkin (1953) points out, is expressed, or summarized, as a single factor in its mathematical effect upon the curve of growth. This fact has important ecological implications. It suggests that it is actually immaterial whether the expression of the density reaction is related to environmental resistance, carrying capacity, competition, intolerance, or other such specific concepts. It is, in a sense, a confirmation of Errington's principle of "compensation." In the case of population growth, the mechanisms may vary, but the effect tends to be the same.

A great body of data has accumulated describing the operation in relation to density, of various mechanisms such as those mentioned above. The exact operation may involve quantitative physical factors, such as food or space; "psychological" factors such as intolerance, or even completely intangible things that we have not yet understood. But in effect, all of them ultimately operate to either curtail reproduction, or increase mortality, as density rises. This relationship of density, mortality, and natality, was as Thompson (1943) points out, expressed by the British physician, William Farr, as early as 1843. (It seems to be the provocative truth that many such basic principles of modern game management were originally suggested in one form or another 50 to 100 years ago.)

Longhurst *et al.* (1952, p. 77) stress the theme in specific terms by reiterating that *"both rate of reproduction and rate of mortality are regulated by the condition of the range."*

The relative importance of mortality versus natality in expressing the density reaction will vary with the type of population involved, and also with changes in the stages of growth, or degrees of density in the population. However, Pearl's (1939, p. 14) generalization probably applies in some degree to most game populations: "It is evident in theory as well as in fact that in the aggregate the forces of natality are naturally and normally more powerful in a statistical sense than those of mortality. The reproductive capacities of animals generally extend over considerable fractions of their individual lifetimes, while each living thing dies only once.'' In other words, an individual animal can, by dying, subtract from a population only once; but it can, by reproducing, add many times.

Pearl defines *fecundity* as the capacity of an animal to produce ova or spermatazoa, and *fertility* as the capacity of mated animals to give birth to living offspring. There is evidence that both fecundity and fertility are sensitive indexes of density reactions, and work such as that of Cheatum and Severinghaus (1950) with the white-tailed deer is clarifying the relationship.

Density, of course, is a relative thing and its pattern of influence on population growth will depend on a number of variables. The relative quality of resources, or the absolute size of the ''universe'' in which growth is being realized are important factors. Thus Leopold *et al.* (1951) describe a relatively high rate of growth accompanying a relatively high density in one segment of the Jawbone deer herd, and Severinghaus (1951) reports a transition from a high initial rate of growth to a critical density effect in a small but confined deer herd in the short span of four years. Under some circumstances there may also be a lag between achievement of a critical population size and the resultant density effect, as Solomon (1949) and Haldane (1953) point out. In most cases in nature, we may expect to find Liebig's Law operating seasonally, over a period of years, or among various environmental factors, to determine how and when the density effect is expressed. Whether the species involved is socially tolerant or highly territorial will also have a great effect upon the characteristics of the density reaction.

The one great discrepancy between the classical sigmoid curve and the actual growth of many game populations is in the nature of the ceiling limit on growth. In theory, and in most experimental populations, this limit has been *fixed,* and growth proceeded toward a fixed ultimate value. In practice, however, many game populations, as they grow themselves, have a corresponding destructive effect upon the resources comprising the environmental capacity for supporting growth. In this case the ultimate limit for population size is not fixed, but will itself be shrinking proportionally as the population grows; and the resultant curve will logically have a greatly foreshortened decelerating phase. This sort of thing seems characteristic of prolonged deer irruptions and similar incidents. Under these circumstances it becomes important to detect the very first departure from accelerating growth, as an indication that deceleration will soon begin.

Optimum yield and the principle of diminishing returns. The sigmoid summation curve, ABC of Fig. 1, may be expressed in a different form—as an increment curve representing the change in size of the individual growth increments per unit time during the progress of the growth cycle. This is represented by the curve ADE in Fig. 1. It will be seen that as this population grew the increments per unit time increased in size to a maximum (point D) at the time of inflection, and thereafter decreased until the population grew no more. This pattern prompted Thompson (1942) to call such a curve the "curve of optimum," and the same relationship in individual organisms has caused Brody (1945, p. 499) to describe the inflection point as the position on the growth curve where "gains are most rapid, and perhaps most economical."

This curve also expresses the well-known principle of diminishing returns. During exponential growth, each increment is proportionally larger than the preceding one; but during the decelerating phase the increments become proportionally smaller as the population increases in size. The bigger it grows, the less it gains. Thus the absolute gain in numbers per unit time in a population at point B, on the curve ABC of Fig. 1, will be greater than at any other point along the curve. If the curve happens to be skewed, the relationship will still hold true.

Significance to management. Perhaps the greatest practical significance of population growth phenomena lies in this philosophy of "optimum yield." Hjort *et al.* (1933) developed a theory of optimum catch in a whale population on this basis, and in recent years, it has been expressed in more familiar terms by Burton Lauckhart (1950, p. 650) in his philosophy that "'we should keep our deer herds 'erupting' at all times, and we should be harvesting that eruption by killing both bucks and does."

The curves of Fig. 1 are a simple and graphic description of this argument. When viewed as a function of population density they show what is basically involved in the familiar exhortation that for better production we should often reduce population size. They are a confirmation of the "supposition that outright removal of part of the deer by hunting may be in some obscure manner a stimulant to successful reproduction" as indicated by Leopold *et al.* (1951, p. 120). There is only one point on the curve, and one stage in the growth or density of a population, where the greatest yield in terms of numbers produced per unit time may be realized. Below that point the population investment is too small, and above it the rate of interest drops off. This yield, of course, is strictly in terms of the number of individual animals produced.

Optimum yield in this sense may differ from the optimum described in experimental biology, where it is related to the maximum rate of growth instead of the maximum increment. It also differs from the optimum used in fishery problems where production is evaluated in total pounds and efficiency of food utilization, rather than by the number of individuals harvested. Optimum yield must also be distinguished from a yield which is merely stabilized. It is theoretically possible to stabilize production at any point along the sigmoid curve, providing the harvest balances the increment associated with that stage of growth. For this reason it may be dangerous to evolve management plans from empirically developed yield figures merely on the strength of their having been known to result in a stabilized population. A much higher yield might often be obtained by modifying the size of the basic population, to bring it either down or up to the inflection point on the growth curve, where production is highest.

In the case of a population which must be managed to hold it below, or bring it down to the inflection point, the problem is one of reducing size, or halting the increase in size, of the population. It was emphasized earlier that increase is actually a function of the female units of a population, given a minimum proportion of males. As long as female units are added to the population it will continue to grow toward maximum but inefficient size. It will therefore be impossible to maintain such a population at the level of optimum yield without harvesting females as fast as they are produced beyond that level—unless males can be removed to the extent that a large portion of the females do not reproduce. This latter alternative would be ridiculous and probably not even possible in many wild populations.

Another significant application of this philosophy to management is in relation to predators, pests, or other populations that may be considered undesirable. In this case, control measures which succeed in reducing total population size may simultaneously stimulate the rate of increase in the undesirable population. This will mean that an increased proportion of animals will have to be removed per unit time in order merely to hold the population at the new reduced level. It is again an optimum yield phenomenon, but in this case contrary to the goals of management. Under a bounty system, of course, it might not be considered quite so contrary from the standpoint of the hunter reaping the increased harvest.

Game management has usually been considered a matter of interest return (harvest) on a capital investment (breeding stock). In most cases the problem actually involves two rates of interest on two types of investment: one in range vegetation or its equivalent, and the other in the number of animals carried on the range. It may be theoretically possible to achieve an exact and desirable balance between these two investments and rates of interest. Yet, such a permanent stability may actually be impossible, since many game populations grow faster than interest accumulates from the range investment. Even if the game population could be precisely held at a level low enough to be supported by the interest alone, the game manager may ultimately be confounded by plant succession, or other inexorable changes in the environment. In the light of these difficulties, the philosophy of optimum yield must become a flexible one, to be combined judiciously with the philosophy of "artificial fluctuations" advocated by Olaus Murie (1951).

AGE DISTRIBUTIONS

Stationary or life table age distribution. The rate at which a population grows is a function of the relationship between natality and mortality—the ratio of births to deaths. When a population has reached the upper end of the sigmoid curve and has ceased to grow, births must obviously just balance deaths. Age distriubtion in such a population takes on a characteristic form which is determined by the course of natural mortality removing animals as they grow older. This pattern of natural mortality is quantitatively evaluated by use of the actuary's "Life Table" (see Dublin *et al.* 1949; Deevey, 1947) and is often expressed in the ecologist's survivorship curve. The survivorship curve for animals in a population that is neither increasing nor decreasing—a "life table" or "stationary" population—also may be interpreted as depicting the age distribution within the population. In this case it may be transformed graphically into a figure roughly bell-shaped to show better the age structure. Characteristically, a stationary age distribution contains a large proportion of middle-aged and old animals. A typical such age distribution. derived from a life table for laboratory voles (Leslie & Ransom, 1940) is shown in Fig. 3.

Stable or Malthusian age distribution. The word "stable" is applied to the age distribution in a continually increasing population because it has been shown (*loc. cit.*) that, eventually, given a constant rate of increase, such a population will achieve a stabilized age distribution which will remain the same as long as the increase continues at the same rate. As can logically be expected, such an age structure will contain a great predominance of young animals. With a high rate of increase, the proportionate representation of the older age classes will so shrink as to become negligible. An example of this type of age distribution is also shown in Figure 3, again as calculated for the laboratory voles. Since this condition is the result of a continued

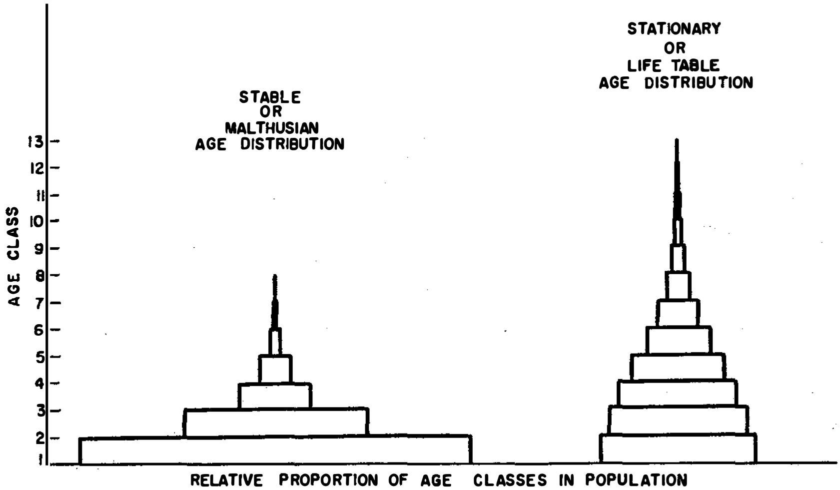

Figure 3. Typical age structures representing an increasing and a stationary population of voles. (Data from Leslie and Ranson, 1940)

constant rate of increase, it is characteristic of a population experiencing the accelerating growth associated with the lower portion of the sigmoid curve; after a period of continued increase, but below the point of inflection where the constant rate begins to drop off.

Significance to management. The stable and the stationary age distributions are characteristic of the extremes at each end of the sigmoid growth curve, and just as the curve experiences a gradual transition from one extreme to the other, so will the proportional balance of old and young animals in the age structure of a growing population experience a corresponding gradual transition between extremes. Thus in the age distribution of a population may be found a reflection and therefore an additional measure of its condition.

Though age structure can be an important index, the natural fluctuations in population that occur from year to year in almost any population must be considered when interpreting age distribution data of the type obtained from checking stations or bag checks. These data commonly reflect the presence of "weak" or "strong" age classes, which may be correlated with poor or good production in the year of their birth. The relative importance of these annual variations in affecting the population as a whole will depend primarily upon the number of age classes comprising the population. Thus the relative rate of increase actually experienced in any one year will have a much greater effect upon total population size in such relatively short-lived species as upland game birds or sardines, than it will in relatively long-lived species such as elk or halibut. For the same reason, any population which, under management, is producing a high yield with heavy cropping—and therefore is composed predominantly of only a few age classes of young animals—will be more sensitive to annual variations in production than another population producing at a lower rate but with a greater representation of age classes. In the latter case, total population size is less dependent upon annual recruitment. This vulnerability associated with greater dependency upon each year's production is one of the risks involved in managing a population for optimum yield.

From yet another angle, the youngest age classes of breeding stock also assume unique importance in a population showing a high rate of growth. Merely because of the proportionally great representation in the age structure of animals in their first year or two of breeding, so will the annual increase be proportionally greatly dependent on their performance. The higher the rate of increase, the greater the predominance of young animals and hence, the greater will be their proportional contribution. Birch (1948), to cite an extreme example, has calculated that, in a certain population of insects composed of 10 age classes in the adult category, over 50 per cent of the rate of increase is accounted for by the youngest age class, and the first two together contribute 85 per cent toward the final value. To go one step farther, it is easy to appreciate the great significance of a relatively small percentage of fawns breeding in a deer population. Even though this percentage be small, it could be of considerable importance to a growing population of which fawns made up a relatively large proportion. Thus it can be seen that by virtue of the age distribution characteristic of a growing population, management for a continuing increase must concentrate upon factors influencing the youngest animals, while it can almost completely disregard the fate of the older animals.

On the other hand, one inevitable result of this type of age structure is that the population becomes so diluted with young age classes that hunters, for instance, will no longer have much chance of harvesting an old and perhaps, to the hunter, more desirable animal. Optimum yield in terms of *numbers* of animals produced is incompatible with the production of old animals, whether it be of trophy bucks or blanket beaver. A population whose highest value is in the production of older and larger animals cannot therefore be required to produce in numbers at all comparable to one stabilized at a high yield level.

Economics of environmental resource utilization are also involved in the different types of age distribution. If two populations of the same size exist side by side, but one tends to the stable age distribution with predominantly young animals, and the other tends to the stationary with more old animals, then the investment in range production, or other resources, represented by the latter population will at any given time be significantly greater than that represented by the former. This must be so, for the population of older animals will represent a larger total number of years of range use as a basis for its existence. Thus it takes a greater investment in range production to yield one unit of harvest from the older population than it does from the younger. The implication for managment is that, besides achieving a higher production of animals under an optimum yield, the resultant development of a young population means more efficient use of the range. This advantage must, of course, be reconciled with the possible desirability, under some circumstances, of producing a certain proportion of old animals.

One other implication of age structure should be mentioned. It has been indicated that age distribution within a population is the joint result of the rate of increase of the population and the pattern of natural mortality operative upon members of the population. If the quantitative value of either of these factors is known, then the other may be deduced from a representative sample of the age structure. This is basically the theory behind the "catch curves" of Ricker (1948) which, though designed for application in fisheries work, are of equal significance in treating game populations. For several years, I have found such "catch curves" to be a useful tool in analysing checking-station data from mountain sheep populations—especially since this species may be aged with considerable accuracy throughout its life. Hayne and Eberhardt (1952) have given an excellent outline of the potentialities of these techniques of Ricker's for use in studying survival in deer populations. The "turn-over" rates of Leopold *et al.* (1943) and Petrides (1949) are another expression of these survivorship phenomena.

In order to make fullest use of the very significant information provided by these measurements of age distribution, a game manager dealing with any species should be able to age his animals with reasonable accuracy *year by year* throughout their life. This is one of the most important single advances yet to be perfected in management technique.

CONCLUSIONS

Life itself is by nature an expansive force, and in the essential economy of nature's ways, this expansion tends to follow a few basic and systematic patterns. In the preceding sections, these patterns have been described, and their significance to game management shown in the light of their effect upon the size and rate of increase, or production, of natural populations of animals. The practical success of game management can be enhanced by an appreciation of these principles developed in theoretical and experimental biology.

The irregularity and constant change that is characteristic of wildlife ecology does not invalidate or detract from these principles, for variations from standard patterns are in themselves significant. The irregularities merely make the job more difficult. The problems of human populations would seem to be more easily understood, yet Pearl (1939) emphasizes their complexities in the pertinent statement of Bertrand Russell, "that ascertainable truth is piecemeal, partial, uncertain and difficult."

There is, of course, a real danger in blind extrapolation, or overenthusiastic analogy, and game management has already suffered from ill-fated attempts to resolve complex problems with simple solutions. Yet, the practical success of insurance companies testifies to the *average* orderliness of events, and as Durward Allen (1954) points out, general patterns are of importance since it is mass phenomena that count in management.

Numerous examples of the evolution and operation of principles could be cited from the wildlife literature, and many of these are coherently described by Allen (*loc. cit.*). Mention of all the significant papers that have contributed to the basic concepts of game management or population dynamics has not been practical in this discussion, but an excellent summary of the latter field is available in Allee *et al.* (1949).

Much has been left unsaid regarding further implications of population growth patterns. There is an obvious relationship with cyclic phenomena, and the fact that populations often "grow" smaller, or decline, according to systematic patterns, is also significant. The question of what can happen to a population after it has reached maximum size is another entire problem in itself. Also, patterns of mortality in populations—the antithesis of growth—appear to be just as systematic as those of growth, and of comparable significance to practical game management. However, these are themselves another complete subject in the productive science of population dynamics.

ACKNOWLEDGMENTS

Dr. P. A. Larkin, chief fisheries biologist, British Columbia Game Commission, originally introduced me to the intriguing potentialities of population dynamics. Professors I. McT. Cowan, A. J. Wood, and W. S. Hoar, of the University of British Columbia, have given additional assistance, and Dr. D. L. Allen and Mr. U. C. Nelson of the

U. S. Fish and Wildlife Service have provided encouragement in developing these ideas. However, none of the above should be held responsible for my interpretation of growth phenomena.

SUMMARY

1. In order to be "practical," game management should be able to produce the best possible results at all times. Certain basic principles of population growth that have been developed primarily in theoretical and experimental biology can promote better results when applied to the practical problems of game management.

2. The classical S-shaped, or sigmoid, summation curve, representing the growth of a population toward its ultimate size limit, has both a mathematical expression and an ecological significance. The constituent segments of such a curve may be analysed separately, for simplicity and a better appreciation of their significance.

3. The lower, concave ascending portion of the curve expresses the tendency of organic growth to proceed in an exponential progression. The *amount* of growth added at any given time tends to be in direct proportion to the size of the growing body at that time, and therefore the relative *rate* of growth remains constant. Continued growth at any constant rate inevitably produces a curve typical of the "irruptive" patterns observed in game populations.

4. There is a maximum limit to all growth, and therefore the initial exponential increase is inevitably halted sooner or later. This curtailment of growth is often expressed first by a reduction in the initial rate of growth, followed by a systematic deceleration in the growth rate as the maximum limit is approached. There is a "point of inflection" in the growth curve where deceleration begins, and the amount of growth added thereafter is at any given time proportional to the amount of growth yet to be made to reach the ultimate limit. This pattern expresses the principle of diminishing returns.

5. Since the decrease in growth beyond the inflection point is contingent upon existing population size as well as upon the ultimate limit to size, the typical growth pattern may be interpreted as a function of relative density, as well as time. The inflection point then represents a threshold density value, and the decelerating phase may be described as a rate of increase inversely proportional to density. This is a familiar concept in game management.

6. In the mathematical description of the sigmoid growth curve, the inhibiting effects of density are summarized as a single factor. Ecologically, this implies that the identity of individual limiting factors is of minor importance in comparison to the ultimate effect which can

be related to density alone. The effect is inevitably expressed by a rise in mortality, or a decline in natality, or both. Variations in natality rather than mortality may usually be considered the more effective in controlling population size.

7. The exact pattern of growth exhibited by any specific natural population will be affected by numerous variables, some of the more important of which are the relative social tolerance of the species, and the effect of the species on the environment resources for supporting growth.

8. The sigmoid growth curve may also be expressed as an increment curve, showing the amount of gain per unit time, or the gain in relation to density. Such a curve clearly shows that at only one point in the stages of growth or density of a population will gains be at a maximum. This relationship graphically fixes the point of "optimum yield," where, in the case of a game population, production will be at its highest. It will be impractical, if not impossible, to hold any population at the level of optimum yield without harvesting females as fast as they are produced beyond that level. In controlling undesirable populations, reduction in numbers may also produce a higher rate of increase in the residual population.

9. Since wildlife populations and the resources of their environment may often grow at different rates, any philosophy of optimum yield must be a flexible one. Artificial or natural fluctuations in production may be inevitable.

10. The age structure within a population may be correlated with its position on the sigmoid curve. A "Malthusian" type of age distribution, with predominately young animals, will characterize the accelerating phase, or a population at the optimum yield level. A "stationary" age distribution, with more older animals, will characterize a population which has reached its limit and has stopped growing. Age distribution can be an additional measure of survivorship and rate of increase in a population.

11. Fluctuations in annual production are normal, and may occur without affecting the trend of growth. The number of age classes comprising a population will determine the relative effect of these annual fluctuations upon total population size. A population at the optimum yield level will be more dependent upon annual production than one yielding less, and thus containing a smaller proportion of young animals.

12. In a high yield population, production by the youngest age classes assumes great importance. The small proportional representa-

tion of old animals in such a population means high yield will be incompatible with production of old animals.

13. A high-yield population can produce more units of harvest from a given investment in range production than can a lightly harvested population with more old animals.

14. Although variation and constant change are characteristic of wildlife problems, the *average* orderliness of events permits the development of general principles and patterns which can be profitably used to evaluate trends and interpret observed irregularities in the day to day practice of game management.

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DISCUSSION

VICE CHAIRMAN DASMANN: Thank you, Mr. Scott. We certainly can't afford to ignore the findings of the statisticians in the laboratories and when we do ignore them we run into difficulty. Mr. Scott's paper has done a very good job of relating these laboratory mathematical findings to wildlife management. It certainly is a paper it would pay to reread several times.

MR. FRED W. JOHNSON (U. S. Forest Service, Missoula, Montana): As biologists we speak of animals in terms of numbers and so on, but when we come to game animals and sport, and think of quality of trophies and quality of sport, it seems to me if I had my way, I would prefer a population of the older age classes, because therein you get all the trophy heads. Besides you have smarter animals to shoot and a better quality of sport. So, in our management objectives, I feel that we should consider those qualities also.

MR. SCOTT: That is a very excellent comment and brings up one of the things that must be resolved on the basis of these factual situations, if you are managing the population to produce old animals, by the very nature of things, you cannot expect it to produce as many animals and manipulation of the sigmoid curve shows that nicely.

On the question of preponderance, if you maintain a percentage population which contains a large proportion of older animals proportionately as on the diagram, it will represent a better investment in range production than will a population containing predominantly young animals. This is by virtue of the additional number of years represented by the older animals; the additional number of years of consumption of range production. And therefore, the optimum yield population will be more efficient in terms of range use as well as in terms of production of individual animals.

However, it is certainly a matter of choice for the hunter and administrator as to whether they wish to produce old animals in fewer numbers or young animals in larger numbers.

MR. FRANK BARICK (North Carolina Wildlife Resources Commission, Raleigh, North Carolina): In a rapidly increasing population, let's say, for example, of deer, do you have any figures as to what percentage of the population is represented in each of those age classes, or do you have it for any other species that might possibly occur?

MR. SCOTT: There are numerous sources of such figures. Levi Mohler in Nebraska gives a check of the age classes, Whitaker and Hunter had a report in the *Journal*, showing the kill figures for Colorado in one year. I remember in the Colorado figures, I believe, about 50 per cent of the kill was taken from the youngest of age classes—yearlings and two-year olds. And I would assume that that certainly is a conservative proportion for a population which is increasing at a great rate and the population that is represented by this graph, the proportion of yearlings might be 30 per cent or even less.

The assumption is, of course, that these checking station figures represent a cross section of the age, distribution and population, which of course, isn't always so. However, they may be interpreted if the differences are known.

MR. RALPH J. ELLIS (Oklahoma A. & M. College, Stillwater, Oklahoma): By optimum yield, do you mean on a sustained yield basis or on a reproduction potential? Is optimum yield that forced carrying capacity?

MR. SCOTT: This refers to Point B, where the maximum of animals are produced from any population size. It is the realization of a potential in a certain sense.

FACTS ABOUT CANADIAN MUSK-OXEN

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Canada has a rare and valuable asset in the herds of musk-oxen (*Ovibos moschatus* ssp.) frequenting her barren-lands and Arctic islands. She shares with Greenland a wild population of these mammals, which is of great scientific value. When their numbers have increased to the point where utilization is feasible, musk-oxen in Canada will be of economic value also.

The complete extermination of many herds and the near elimination of as many others, particularly on the Canadian Arctic mainland in the closing half of the 19th and during the first 15 years of the 20th centuries, created real concern for the survival of this species. To conservationists it was unthinkable that a large ungulate, well adapted to living in a rigorous Arctic environment, should become extinct. The Canadian Government passed an Act in 1917 protecting musk-oxen completely, and forbidding any killing, and in 1927 set aside the Thelon Game Sanctuary in the Northwest Territories for the specific purpose of providing an area where the local musk-oxen and other valuable wildlife could increase without human interference in any form. The number of recent reports recording observations of musk-oxen in many areas, particularly where the animals were thought

[1]In the absence of Mr. Tener, this paper was read by Dr. Frank Banfield.

to have become extinct, suggests that the regulations and the sanctuary are having the desired effect.

As part of the general policy of assessing the wildlife resources of the Canadian Arctic, the Canadian Wildlife Service initiated a specific investigation in the spring of 1951 to determine the distribution, numbers, and biology of musk-oxen. Two populations of musk-oxen have been studied to date, one in 1951 on Fosheim Peninsula, Ellesmere Island, N. W. T., 700 miles from the North Pole, and the other in 1951 and 1952 in the Thelon Game Sanctuary, N. W. T., over 1,000 miles to the south. This report is a brief review of the findings of these studies, together with certain historical information obtained from earlier researchers and writers.

DISTRIBUTION

At one time, before they were hunted for the value of their skins and for food by natives, whalers, and explorers, musk-oxen had a wide, if relatively sparse, distribution throughout the barren-land regions of the Arctic mainland and Arctic islands of Canada. One important exception to this is that there are no known records of musk-oxen on Baffin Island, possibly because of their extinction long ago by natives, or because this island, for reasons unknown, was never colonized by musk-oxen.

The total numbers in existence at the time of Samuel Hearne in the 1770's are unknown but probably were very few when compared with original numbers of caribou. Hearne has provided evidence that even in his time musk-oxen were restricted in numbers and distribution for he has commented on the fact that he traveled for days over the Arctic mainland without seeing any. From 1862 to 1916 the Arctic mainland population was drastically reduced. Musk-oxen were killed for their skins for trading purposes and for skins and meat for whalers wintering along the Arctic coast east of the Mackenzie River delta. The Hudson's Bay Company generously has made available to the Canadian Wildlife Service its records of musk-ox furs turned in to its posts in northern Canada. From 1862 to 1916 a total of 15,101 skins were received by this Company, of which 5,408 were turned in from 1888 to 1891. These figures must be regarded as a minimum kill of musk-oxen during this period of 58 years, for whalers and natives would have kept many skins for their own use.

On the Arctic islands similar heavy killing is recorded. In the name of exploration 400 animals were killed on Melville Island early in the present century as were several hundred on Ellesmere Island at the same time. The population on Banks Island was exterminated by natives before 1870. The result was that by 1930 the population of musk-oxen in Canada was estimated by Dr. R. M. Anderson, National Museum of Canada, to be between 9,000 and 10,000 animals, of which 500 were on the mainland, including 250 in the Thelon Game Sanctuary.

Today the picture is a happier one. Musk-oxen are increasing steadily, if slowly, in numbers and are being reported in areas such as Banks Island and the area north of Great Bear Lake, where formerly they were believed to have been exterminated. The population in the Thelon Game Sanctuary is believed to be over 500 animals and shows every indication of increasing at a healthy rate.

SOCIAL STRUCTURE

Musk-oxen are essentially gregarious, feeding and traveling in herds. The size of herds varies from small units of four or five animals to as high as one hundred. Generally, the large herds are the aggregations of the small units, formed after the breeding season has finished.

Mature bulls are an exception, for they are not as gregarious as other animals, frequently being solitary in their habits. This is particularly true before and after the breeding season.

Herds exist throughout the year but probably do not contain the same individuals from year to year, because of the mingling of herds in the autumn and the general dispersal afterwards into smaller units.

When grazing or browsing, the individuals of a herd may be spread over an area of several hundred square yards, but the herd unity is not lost, for individual cows or immature animals that have become more widely separated from other individuals than is customary, rejoin the herd immediately upon noticing their unusual situation.

The desire to remain in herd formation appears to be an outstanding characteristic of these animals. The value and perhaps the original function of this social character is evident when a herd is attacked by wolves. The musk-oxen group together in a rough circle, facing outwards, with calves and immature animals between the adults. One wolf or a small pack would not be likely to attack successfully such a defensive formation. The sharp, heavy horns of adult cows and bulls, a heavy coat of long hair, nimble feet and powerful bodies make them formidable opponents. When sled dogs attack musk-oxen, and probably when a large pack of wolves does so, bulls and adult cows make short dashes towards the predators in attempts to gore them and then back into the herd. Under these circumstances it is possible that some musk-oxen would be killed.

FOOD AND RANGE

Food of musk-oxen varies with the season and the terrain. In summer, on the Canadian Arctic mainland, the animals are browsers and grazers, feeding on willow, grasses, forbs and sedges. On the Arctic islands willow growth is confined to prostrate plants sparsely scattered over large regions and musk-oxen must use a larger proportion of grasses and plants such as saxifrage (*e. g. Saxifraga oppositifolia L.*) and dryas (*Dryas integrifolia* M. Vahl.).

On Fosheim Peninsula, Ellesmere Island, where range studies were carried out, it was found that 85.5 per cent of the surface of the spring and summer range under study was rock, gravel, silt, and clay. The total vegetative cover was 14.5 per cent, of which grasses composed 4.8 per cent and willow 2.5 per cent, of the 10,000 points sampled by the Clarke Point Sample Method.

Winter food is obtained in hilly country where vegetation is kept partly or completely free of snow by prevailing winds. Dried grasses of *Poa, Alopecurus, Agropyron, Arctogrostis* and *Festuca* genera and dried forbs are the main food species at this time of year.

The extent of the seasonal movements between winter and summer ranges depends upon the nature of the country in which the animals live. In the Arctic islands preliminary evidence suggests that these movements do not involve distances of more than 50 miles. On the mainland of Canada evidence suggests that musk-oxen there may move a distance of 50 to 100 miles or more to reach suitable feeding areas.

BREEDING BIOLOGY

Much remains to be discovered about the reproductive biology of these ungulates. Their remote environment and relative scarcity make it a difficult and expensive undertaking to try to conduct the continuous long-term investigation necessary to gather the facts.

Some information is available, however. It is believed that musk-ox cows are sexually mature at four, possibly at three years of age, and bulls at five or six years of age. Cows do not seek a solitary spot to give birth to young , but remain with the herds of which they are members. Evidence obtained during the present study suggests that calving occurs in alternate years with one calf delivered at a time. Twins are born rarely. Reasons for the low reproductive rate are as yet unknown, but an important factor may be a lactation anoestrum in cows that have suckling calves. This would prevent conception during the year a calf was born, with the result that there would be no birth the following year. This argument has some merit at present, for in all cases where a yearling has been observed in association with a cow, that cow has been without a calf. Other factors, of course, may prevent calving each year, but as yet their nature remains to be determined.

Breeding occurs in late July and August and the calving season extends from about the middle of April to the end of May. These dates appear to be true for the entire range of musk-oxen, which is spread over a distance of 1,100 miles, from latitude 64° N. to 82° N.

It is interesting to speculate what the nature of the mechanism controlling this apparent uniformity of breeding dates may be. There is a growing body of literature concerned with the influence of light, or alternating periods of light and darkness, on the onset of breeding in mammals. It is possible that light influence is a major factor in musk-oxen breeding and calving times. The northern and southern limits of musk-ox distributional range have markedly different light conditions. At latitude 80° N. on Ellesmere Island, the habitat of at least 500 musk-oxen, there is darkness 24 hours a day from October 22 to February 20. Daylight increases in length until April 14, from which date until August 31, it is continous. At latitude 64° N. in the Thelon Game Sanstuary, however, 24-hour daylight or darkness does not occur. On June 21 there is a maximum of 18 hours sunlight, which decreases to four hours December 21.

In review, then, periods of sunlight grow shorter before musk-oxen commence to breed in the Thelon Game Sanctuary, but the sunlight on Fosheim Peninsula is of 24 hours a day duration throughout the mating period. It would appear that if alternating periods of light intensities initiate the onset of oestrus in musk-oxen, this mechanism must act on the animals before the onset of maximum daylight to have uniformity in breeding dates. There is a suggestion that this causal mechanism may be associated with the changing light periods before and during the spring equinox.

Fighting between adult bulls for the possession of herds and essentially of cows, occurs chiefy during the months of July and August. Sporadic fighting at other times of the year does not appear to be significant as far as herd dominance is concerned. In all cases observed by this writer, bulls in possession of herds were well-matured animals. Solitary bulls, on the other hand, ranged from mature young animals to the very old. A combination of experience and strength is probably necessary for the successful conclusion of conflicts for cows. As immature animals are tolerated in a herd until they reach sexual maturity full fighting experience would not be gained until after the fifth or sixth year of age.

VITAL STATISTICS

The determination of the numbers of the various age and sex classes in herds, apart from calves and adults, is uncertain because of the difficulty in correctly identifying immature animals. Information obtained to date on adults indicates there are more cows than bulls, the proportion on Fosheim Peninsula, Ellesmere Island, being two cows for each bull, and in the Thelon Game Sanctuary, 1.2 cows for each bull. These proportions may not represent a true picture because the solitary habits of many bulls makes it doubtful whether all were counted. The deferred maturity of bulls may distort the adult sex proportion and so may increase mortality of bulls because of predation when they are solitary in their habits.

The calf percentage in a musk-ox population is low when compared with many other ungulates. On Fosheim Peninsula, for example, calves in 1951 composed 9.3 per cent of 215 animals, and in the Thelon Game Sanctuary in 1952 they were 11.2 per cent of 169 musk-oxen. Calf survival was found to be extremely low in 1951 on Ellesmere Island, only three yearlings being present in the population studied. In the Thelon Game Sanctuary, however, survival was found to be slightly over 60 per cent, for a survey in 1951 revealed a calf percentage of 11.8 in the total population, and in 1952 the yearling percentage was 7.1 in the same population, a drop from the calf numbers of 39.8 per cent.

MORTALITY FACTORS

The knowledge and importance of mortality factors in musk-ox populations are as yet unknown. There is evidence to suggest that the wolf may be a mortality agent. Numerous instances in the literature record the killing of musk-oxen, chiefly solitary animals and often bulls, by wolves. Musk-ox remains have been found in wolf scats and wolf stomachs, but this only suggests that wolves will eat musk-oxen, not that they have killed them. A musk-oxen herd presents a formidable defense to wolf attacks, but it is believed that calves and yearlings could be taken by a large pack of wolves, even though protected by the herd.

The scarcity of yearlings found in herds on Fosheim Peninsula suggests an appreciable mortality of this group. Adverse weather during the period of birth in April and May, harsh environmental conditions during the first winter of a calf's life, and perhaps wolf predation, are possible important mortality factors.

In conclusion, Canada's musk-oxen, in the rather distant future, should become an increasingly valuable big game resource. From a scientific viewpoint they present extraordinarily interesting problems of research and management. From an economic viewpoint they may again reach the level of abundance where utilization may be permitted by natives or resident white people. It is hoped that by eventual restocking of depleted areas and careful management of existing stocks, musk-oxen once more will be game animals of more than scientific interest.

DISCUSSION

DISCUSSION LEADER DASMANN: Thank you, Dr. Banfield. There is some very important work going on, on these animals. Do we have any comments or questions from the floor? If there are any of the Alaska people here, it might be interesting to know what the status of musk-ox is over in Alaska.

MR. URBAN C. NELSON (Fish and Wildlife Service, Juneau, Alaska): In a survey just completed on the herd, the figures that I recall are 80 or 90 animals, which is a good increase over the last year.

MR. RICHARD W. HESS (University of Maine, Orono, Maine): Did you mention the average life span of these animals? You said the cows become mature at four years. What is the average life span of the adults?

DR. BANFIELD: I don't think Mr. Tener has any data on that.

DR. JOHN L. BUCKLEY (Cooperative Wildlife Research Unit, Alaska): We have one record of longevity of an animal born in the spring of 1950 in Greenland and transplanted to Alaska, which died during the winter of 1952-53. We are certain of this because it had Tag No. 34 in its ear, and we had a complete record on it for that length of time.

Out of 90 animals, we found in addition, two dead ones, and the count last year was 75. However, we may have missed two or three animals the year before. But, we had better reproduction in the past year than we have had at any time prior to that.

METHODS FOR CENSUSING WINTER-LOST DEER[1]

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Big-game administrators and researchers frequently find need for appraisals of the winter mortality sustained by deer herds. Concern over deer losses is especially manifested during winters of unusual severity when mortality has been high. Not only are the technicians and administrators desirous of evaluating herd losses, but so are many sportsmen who became alarmed and feel that curtailment of hunting removals during the subsequent season may be necessary.

It is one thing to decide that losses should be evaluated and quite another to make the evaluations. Many different methods have been used for determining winter losses. Taylor and Hahn (1947) censused live deer both before and after winter on a study area and prescribed the difference between the two censuses to winter mortality. Over-winter changes in the age ratios of the live deer together with age ratios of the deer which have died offer another means of appraising winter herd losses (Robinette, 1949). The Lincoln Index (Lincoln, 1930) can be used when carcasses are marked on a pre-census survey and the proportion of all carcasses which were marked determined from a subsequent survey made preferably at right angles to the pre-census survey (Robinette *et al.*, 1952). Most determinations, however, are derived by sampling through various kinds of strip censuses. These sampling results are then applied to the entire areas which were sampled. Some strip sampling techniques employed or proposed for use by big game workers are: (1) complete coverage of sample strips of predetermined width, Severinghaus (1947), R. C. Guettinger (letter of January 22, 1951) and others have used this method for winter losses and Costley (1948) employed it for appraising deer crippling losses. Some prior knowledge is necessary of visibility conditions which will be encountered along the cruise line so that the

[1]This study is a contribution by the Utah Cooperative Big Game, Livestock and Range Relationship Research Project conducted jointly by the Utah State Fish and Game Department, U. S. Forest Service, Utah State Agricultural College and U. S. Fish and Wildlife Service.

width of strip on which deer carcasses can be observed is approximately known; (2) methods where the width of strip is determined from distance records obtained for the observed carcasses. The writers know of four methods under this category. They are: (a) King's grouse census method (Leopold, 1933)—in which the average sight distance (*i.e.,* distance from the observer to each carcass when first seem) is doubled to give the "effective width" of the census strip. DeBoer (1947) and Robinette *et al.* (1952) have used this method; (b) Webb's snowshoe hare census method (Webb, 1942)—in which the perpendicular distances of the observed carcasses from the line of travel are averaged and doubled to give the width of surveyed strip. Leopold *et al.* (1951) employed this method with the Jawbone deer herd in California. (c) Hayn's method (Hayne, 1949) is a modification of King's census method, in which subpopulations for different sight distance classes are determined and added for an estimate of the total population. The writers know of no published accounts in which this method has been used for censusing dead deer but Hayne (letter of March 24, 1952) stated he saw no reason why it could not be. (d) Kelker's belt transect method (Kelker, 1945) is a method in which the perpendicular distances of the carcasses from the line of travel are segregated into classes or belts. Half of the "effective width" of survey strip is determined through inspection as the point where the number of observations per belt starts to diminish. Computations are restricted to the number of carcasses observed within the "effective strip." The writers developed this method independently in 1949 before learning that Dr. Kelker had been teaching it to students in wildlife management for the past several years. Kelker has proposed this method for censusing live animals but it appears suited for censusing dead deer as well.

The writers first became concerned about reliability of results obtained from the different methods when it was realized that for any set of deer carcasses observed on a survey the calculated population would always be greater from Webb's method than from King's. This is true because the average perpendicular distance of the observed carcasses from the line of travel will be less than the average sight distance for the same set of observed carcasses. The only exception would be if all carcasses are first observed exactly at right angles to the line of travel—a highly improbable condition. Thus, if Webb's method yields a given number of dead deer for a certain width strip and King's yields the same number on a wider strip the population derived from Webb's method will exceed that from King's. Obviously both methods cannot be valid—at least one is in error. The writers became further interested in the different methods when Hayne

(1949) took exception to King's grouse census method and proposed a modification which tends to give substantially greater results. It was because of these discrepancies that the writers decided to test several sampling methods for reliability and practicability in general field use.

Failure to anticipate a few sources of error resulted in a trial and error type of a study. However, encountering these pitfalls proved invaluable to the writers and their discussion may assist others in avoiding them.

The writers gratefully acknowledge assistance given in field surveys by the following individuals: John Day, sportsman; E. D. Stapley, game warden, and Jess Winn, district game manager, both of the Utah State Fish and Game Department; and Robert Scholz, Assistant Forest Ranger, and the late Kenneth Bower, forest ranger of the U. S. Forest Service.

METHODS

The first testing was done on scattered units in central Utah for winter deer losses in the spring of 1949. Initial findings indicated that Hayne's and Webb's methods gave higher loss values than the other three methods which were being tested (Lincoln Index, Kelker's and King's).

In the spring of 1950 it was decided to conduct repeated and more intensive surveys on a smaller unit of winter range. Accordingly, the boundaries of a square mile of winter deer range located within the north Oak Creek unit in central Utah were flagged off for intensive surveys of deer mortality. About half of the area consists of a flat covered with sagebrush (*Artemisia tridentata*), juniper (*Juniperus utahensis*) and limited amounts of bitterbrush (*Purshia tridentata*). The remaining half is broken up by a number of ridges and draws where juniper, cliffrose (*Cowania stansburiana*) and sagebrush are the principal vegetal components. The unit is typical of much of the winter deer range in central and southern Utah. A number of deer were known to have died on the area during the winter of 1948-49 so it was sampled for deer that died during that winter as well as the following winter of 1949-50.

Four separate surveys (two afoot and two on horseback) were made on the area in 1950. Two randomly selected cruise lines were taken within each one-tenth mile belt on the area so that each survey consisted of 20 miles of cruise line. Odd-numbered surveys were taken in a north-south direction, whereas the even-numbered surveys were made at right angles or in an east-west direction. When a carcass was sighted the observer dismounted, if riding a horse, and paced to the carcass for the sight distance and back to the line of travel for the perpendicular distance. Participants checked their pacing on measured courses prior to the surveys. Each carcass from the winter of 1948-49 was marked for future identification by wiring on a small piece of cloth, care being taken to tuck the cloth beneath the carcass so chances of seeing marked carcasses on subsequent surveys would not be enhanced. Carcasses of the current winter (1949-50) were similarly marked except that a numbered aluminum tag was also attached. On subsequent surveys a record was kept for each carcass found as to whether or not it had been marked previously, thus providing a means of using the Lincoln Index in appraising mortality. A compass and foresights on distant landmarks were used by the observers as aids in staying on the survey lines.

In the following summer (1951) three added surveys were made on the square mile not only to obtain information on the deer loss during each of three different winters, but also, to see how closely results from the various methods would check with the known number of carcasses from the winter of 1948-49 which had been marked during the 1950 surveys.[2] In general, surveys on the square mile gave results quite similar to those obtained on scattered range units in 1949. Hayne's and Webb's method gave values somewhat greater than the other three methods being tested. Checking method results against a known number of carcasses previously marked, however, were inconclusive for no significant differences between survey results and the known population were obtained for any of the methods. However, it was of interest that mean survey results for King's method agreed most nearly with the known population followed by Kelker's, Hayne's and Webb's (the Lincoln Index was not used for no added marking of the 1948-49 carcasses was done on the 1951 surveys). Lack of significant differences for any of the four methods appeared attributable to an insufficient number of surveys, inadequate size of each survey and/or the small population being sampled.

To overcome the foregoing objections the writers, in the summer of 1952, flagged the square mile at one-tenth mile intervals and placed two burlap sacks at random within each one-tenth mile block making a total of 200 sacks on the area. Two random numbers were drawn to determine the location of each sack. Sagebrush was placed within

[2]Ordinarily the writers have restricted winter loss surveys to two age classes of carcasses—current (those dying during the preceding winter) and 1-year old. However, in 1951, we attempted to age 2-year old carcasses in addition on the square mile. We believe the action permissible and practicable in this specific instance for there were several marked carcasses on the area to serve as frequent visual aids in the aging of unmarked carcasses. The degree of weathering of the hair and disintegration of the skeleton serve as criteria for judging the age of the carcass. Small amounts of badly weathered hair still persist about 2-year old carcasses under the semi-arid conditions of Utah.

each sack to simulate the bulk of a dead deer. Four horseback surveys were made for the sacks—similar in every respect to the 1950 dead deer surveys except that a different colored cloth was used on each survey to mark the sacks found so that results from the Lincoln Index could be appraised on the basis of individual surveys rather than from an accumulated total as had been the case with the marked carcasses. Also, instead of pacing the sight distance directly as had been done with the dead deer we paced along the line of travel until at right angles to the observed sack and then to the sack for the perpendicular distance. The sight distances were later calculated in the office from the two field measurements. The writers feel that increased accuracy was attained for the perpendicular distances by using this method.

Survey results showed that the Lincoln Index and Kelker's methods gave satisfactory results but King's was uniformly low and, although Hayne's and Webb's were too high, Webb's method gave relatively lower results than had been obtained from the dead deer surveys. We naturally wondered if this condition was attributable to some constant sampling bias or whether the relationship of census method results on the dead deer surveys were in error. It was the feeling of some of the participants that in the process of trying to maintain straight cruise lines on the sack surveys we had devoted too much of our time searching for marker flags at the expense of looking for sacks. On the dead deer surveys we had maintained our lines by keeping some object in the foreground lined up with a distant landmark which required much less time and diversion than searching for flags in the rather dense cover of junipers.

From a perusal of the data it appeared that although we apparently had seen most of the sacks within close proximity to our lines of travel, we had observed many others at considerable distances while looking for flags. Several distances were in excess of 100 feet and one even for 534 feet. It can be appreciated that addition of these large observational values, both sight and perpendicular, without a compensating increase in the number of observed sacks would tend to give reduced census values for Webb's and King's methods. Results from Kelker's, Hayne's and Lincoln's methods, however, were influenced little if any. Kelker's method makes use of only the observations which are closest to the line of travel where we were apparently seeing all of the sacks anyway. An examination of Hayne's formula will show that the long observational distances have little influence on census results. Likewise, results from the Lincoln Index were unaffected because observational conditions were such that there appeared no reason for the proportion of marked sacks observed at long distances to differ from those noted at short distances.

Because of the questions raised by the sack surveys it was felt necessary to conduct another series of sack surveys. A time lapse of four months since the Oak Creek sack surveys made it necessary to move to another area for there was no assurance that all of the 200 sacks still remained on the square mile. Consequently an 80-acre, nearly level field of sagebrush near Cedar Fort, Utah was selected for the second set of sack surveys. About one-fourth of the area had been burned over at some time in the past resulting in a cover of dry cheatgrass (*Bromus tectorum*) and dead stubs of sagebrush. This cover condition was not believed important at the time but analyses of survey data revealed it probably influenced results from the Lincoln Index. Two hundred sacks were again placed out at random, this time four within each 4 $\times$ 4 chain block (66 feet = 1 chain). Flags were placed out at four-chain intervals along the boundary fence only. The flags were clearly visible across the field and this factor plus a line-up on distant landmarks enabled those making the surveys to remain on their line with a minimum of diversion from the primary purpose of looking for sacks. The four surveys were made by two of the writers afoot.

It may seem a questionable practice for the individuals who placed the sacks out or who marked carcasses on initial surveys to participate in subsequent censuses because of the possible influence which knowledge of sack or carcass locations might have. A number of precautionary measures were taken by the writers to obviate or minimize this possible source of error. Precautions taken included: (1) use of different individuals as much as possible; (2) rotation of participants to different belts during the resurveys; (3) reversal of cruise line directions on the different belts and alternation of north-south with east-west surveys; (4) each participant was made fully aware of the purpose and importance of the surveys and was advised to remain on the cruise line and look no more or less diligently if approaching a known sack or dead-deer location; and (5) participants followed survey lines whose locations were determined by drawing of random numbers.

If knowledge of sack or dead deer locations introduced an appreciable error in census results one could expect decreasing values in population estimates from the Lincoln Index with successive censuses on the same area. If an individual purposely sought out or looked more intently for objects of known location and consequently objects previously marked, he would obtain data which would indicate a higher proportion had been marked than actual, resulting in depressed population values. Such a decline appears in the Oak Creek sack survey results but there would seem to be little if any bias because mean results were within one per cent of the known population. No decline was evident in consecutive survey results for the Lincoln Index on the Cedar Fort surveys nor the Oak Creek dead deer surveys. It also seems noteworthy that results from the different methods on the seventh dead deer survey produced as good an overall agreement with the mean census results for the seven surveys as was obtained for any of the other six surveys. This particular survey was made by two individuals who were new to the area and consequently unacquainted with carcass locations. We feel that appreciable error resulting through knowledge of carcass or sack locations was avoided.

RESULTS AND DISCUSSION

Table 1 lists three census results from four methods for the Oak Creek square mile where the known population was 38.4 marked deer carcasses. As mentioned earlier these results were inconclusive, owing to wide sampling variations. However, it seems noteworthy that results from King's method gave the closest fit to the known population followed by Kelker's, Hayne's and Webb's.

Table 2 lists population estimates for the total number of deer carcasses present on the Oak Creek Square mile from the winter of 1948-49. The total population remains unknown but results from the Lincoln Index and King's methods agree fairly well, Kelker's is somewhat higher with Hayne's and Webb's being considerably greater.

TABLE 1. POPULATION ESTIMATES OF MARKED DEER CARCASSES ON SQUARE MILE NEAR OAK CREEK FROM FOUR SAMPLING METHODS AND THREE SURVEYS, KNOWN POPULATION—38.4, EACH SURVEY—20 MILES OF SURVEY LINES.[1]

	Method				
Survey no.	King	Webb	Hayne	Kelker	No. of observations
1	31.6	53.2	35.3	28.4	12
2	32.8	54.9	48.9	51.5	10
3	47.8	91.9	52.7	48.4	11
Mean	37.2	66.7	45.6	42.8	11
Departure from 38.4	3.1%	73.7%	18.7%	11.5%	
Standard error	5.03	12.63	5.28	7.24	
Standard error as fraction of mean	0.14	0.19	0.12	0.17	
Confidence limits (5% level)	14.5-59.9	12.4-121.0	22.9-68.3	11.7-73.9	
Probability of "t" value[2]	0.83	0.17	0.31	0.56	

[1]Not infrequently deer carcasses are torn apart and the parts scattered by predators or scavengers. To prevent inflationary results in the computations we assigned fractions such as 0.15 for each leg found, 0.10 for a head and 0.30 for the remaining vertebral column and attached ribs.

[2]"t" values were derived by dividing difference between survey means and the known population by the standard error.

TABLE 2. POPULATION ESTIMATES OF DEER CARCASSES FROM WINTER OF 1948-49 ON OAK CREEK SQUARE MILE FROM FIVE SAMPLING METHODS AND SEVEN SURVEYS, TRUE POPULATION UNKNOWN, EACH SURVEY—20 MILES OF CENSUS LINES.

	Method					
Survey no.	Lincoln Index	King	Webb	Hayne	Kelker	No. of observations
1	....	65.5	127.2	80.3	89.7	13
2	43.5	57.0	88.4	134.3	94.4	17
3	40.2	54.4	68.5	62.8	44.4	17
4	50.7	50.6	104.6	72.9	68.7	17
5	54.4	52.5	84.6	67.5	54.2	17
6	42.2	37.4	64.7	54.2	60.3	11
7	52.6	53.5	139.5	79.9	66.0	15
Mean	47.3	53.0	96.8	78.8	68.2	15.3
Standard error	2.46	3.20	10.76	9.89	6.86	
Standard error as fraction of mean	0.05	0.06	0.11	0.13	0.10	
Confidence limits (5% level)	41.0-53.6	45.7-61.3	70.4-123.2	54.6-103.0	51.4-85.0	

Results from supplemental winter deer mortality surveys which the writers have made show the same relationships to one another as found in Table 2 in that Hayne's and Webb's methods give substantially higher estimates than the other methods. Notable among these supplemental surveys was one conducted on the Meadow Creek area, where relatively heavy sampling was resorted to, 78 carcasses or parts being observed (reported in part by Robinette *et al.*, 1952). Here calculated loss values of 239, 259 and 250 deer respectively were derived for the Lincoln Index, King and Kelker methods, representing unusually close agreement. The Webb and Hayne methods, however, gave estimates of 452 and 381, respectively, greatly exceeding the others.

Our supposition that the added distraction offered by flag searching in order to remain on census courses in the Oak Creek sack surveys may have depressed census results for King's and Webb's methods (Table 3) seems verified by calculations in Table 4 for the Cedar Fort sack surveys. It may be noted that mean results from the King and Webb methods were both greater in the second survey to assume somewhere near the same relationship with results from the other census methods as derived from earlier dead deer surveys.

Whereas the Lincoln Index gave satisfactory results on the Oak Creek sack surveys, it did not on the Cedar Fort surveys. Despite mean results only 10 per cent below actual, the exceptionally small standard error (only 1.1 per cent of the mean) and highly significant (at the one per cent level) departure of mean results from the known population indicated a definite sampling bias. It is our belief that extremes in visibility conditions imposed by the burned and unburned sagebrush types were responsble. Inasmuch as sacks placed in the burned areas were visible at greater distances than those in the live

TABLE 3. POPULATION ESTIMATES OF BURLAP SACKS ON SQUARE MILE NEAR OAK CREEK FROM FIVE SAMPLING METHODS AND FOUR SURVEYS, KNOWN POPULATION—200, EACH SURVEY—20 MILES OF LINES.

	Method					
Survey no.	Lincoln Index[1]	King	Webb	Hayne	Kelker	No. of observations
1	211	197	310	391	243	89
2	207	151	206	323	185	64
3	189	181	269	327	169	80
4	186	133	183	278	237	69
Mean	198	166	242	330	208	76
Departure from 200	1.0%	17.0%	21.0%	65.0%	4.2%	
Standard error	6.29	14.43	29.05	23.24	18.52	
Standard error as fraction of mean	0.03	0.09	0.12	0.07	0.09	
Confidence limits (5% level)	178-218	120-212	150-334	256-404	150-267	
Probability of "t" values	0.79	0.10	0.25	0.01	0.68	

[1]The population value listed for Survey 1 for the Lincoln Index was derived through the proportion of sacks marked on Survey 1, which were found on Survey 2 made at right angles to Survey 1. The value listed for Survey 2 was derived from proportion of sacks marked on Survey 2 found on Survey 3 and values for Surveys 3 and 4 were derived from Survey 4 findings through the proportion of sacks marked on Surveys 1 and 3 respectively.

sagebrush a higher proportion were observed and marked. It follows that on the subsequent survey made at right angles to the preceding one, proportionately more of the sacks in the burned area would again be seen than in the heavier cover. Field records thus indicated that a higher percentage of the sacks in the entire pasture had been marked on the initial survey than actual, resulting in depressed population values.

Stratified sampling would probably have eliminated the error noted above. The estimated sub-populations for the burned and unburned areas should have been computed separately and added for a pasture

TABLE 4. POPULATION ESTIMATES OF BURLAP SACKS ON 80-ACRE TRACT NEAR CEDAR FORT FROM FIVE SAMPLING METHODS AND FOUR SURVEYS, KNOWN POPULATION—200, EACH SURVEY—5 MILES OF LINES.

	Method					
Survey no.	Lincoln Index[1]	King	Webb	Hayne	Kelker	No. of observations
1	175	222	289	413	184	153
2	182	174	277	295	200	126
3	180	192	281	276	178	160
4	184	173	271	267	165	158
Mean	180	190	280	313	182	149
Departure from 200	10.0%	5.0%	40.0%	56.5%	9.0%	
Standard error	1.94	11.45	3.77	33.92	7.26	
Standard error as fraction of mean	0.01	0.06	0.01	0.11	0.04	
Confidence limits (5% level)	174-186	154-227	268-292	206-422	159-205	
Probability of "t" values	<0.01	0.46	<0.01	0.05	0.09	

[1]Population values for the Lincoln Index were obtained in same manner as explained in footnote to Table 3.

estimate. Unfortunately this was not done but it sounds a warning for those wishing to use the method in areas displaying observational extremes.

In the analysis of the reliableness of results derived from the various methods on the sack surveys the writers have used the "t" test. This test was applied to the difference between the mean of survey results for each method and the known population of 200 sacks for each of the two areas (Snedecor, 1946). The writers feel that for reasons given previously results from King's and Webb's methods on the Oak Creek area and Lincoln Index on the Cedar Fort area should be disregarded in this analysis because of apparent sampling bias.

Accordingly, the probabilities of the "t" values indicate that Haynes' and Webb's methods gave results significantly in excess of the true population at the five per cent level. Probabilities of 0.01 on the Cedar Fort area and slightly under 0.05 on the Oak Creek area for Hayne's method would indicate that it is probably not adapted to censusing of dead deer or other inanimate objects. Probability of the "t" value derived for Webb's census method results at Cedar Fort is substantially less than 0.01. Contrastingly, probabilities for the Lincoln Index, King's and Kelker's methods indicate that reliable results may be expected providing the requirements of adequate and proper sampling are complied with.

The writers lack the mathematical acumen to explain why Webb's and Hayne's methods have given excessive results. In fairness to Webb it should be stated that he probably would not recommend his method for dead deer surveys. He used it, rather than King's method, in censusing snowshoe hares to compensate for a suspected error occurring through movements of the hares away from the observer at the larger "jumping angles." Hayne (1949), however, has shown that the correction offered by Webb bore no logical relationship to the suspected error.

Although results obtained by the writers indicate that Hayne's method is not adapted to censusing of inanimate objects, we are not prepared to say the same is true for live animals. However, there is some circumstantial evidence that his method may give inflated results on ruffed grouse censuses. King (verbal communication) told the senior author that exceptionally close agreement was obtained in estimates from his census method and the Lincoln Index during intensive grouse census studies in Minnesota. Our results with dead deer gave similar agreement of results from these two methods which in turn agreed reasonably well with a known population. Hungerford (1951) has found that Hayne's method generally gave higher census results for ruffed grouse in northern Idaho than other methods which he employed, including King's method, drumming and brood counts. Basically the writers can see little difference in censusing a live animal such as the ruffed grouse, whose flushing habits seem to adapt it admirably for censusing by the strip method, and the censusing of inanimate objects. Many mammals do not adapt themselves to the strip census method because of their habits of hiding or sleeping in burrows, hollow trees, etc. during the daytime. In addition Hayne (1949) has pointed out that the strip type of census is not adapted to species whose flushing distance may exceed the range of visibility. This objection excludes many additional mammals, as well as birds, from the list of animals which might be censused satisfactorily by the strip method. Even the pheasant may be considered a doubtful subject for the strip census method because of its tendency many times to run and escape unseen rather than flush (Clifton Grenhalgh, verbal communication; Smith, 1948).

In addition to the inaccuracies noted for Hayne's method in censusing inanimate objects another objection which might be raised is that population estimates from his method vary with the accuracy with which the flushing or sight distances are measured. For example population estimates will be greater if the distances are taken to the nearest foot than if taken only to the nearest yard providing there is more than one observation in each yard class.

Of the methods tested which appear usable on deer mortality surveys, *viz.*, Kelker's, Lincoln Index and King's, the writers favor King's. The advantages we believe are many. Foremost perhaps is that strict adherance to a straight line course is not essential such as with Kelker's method where a definite predetermined course line (and under most conditions necessarily a straight one) must be followed if perpendicular flushing or sight distances from the line of travel are to be determined. This added freedom gives the user of King's method greater opportunity to search or look for dead deer and tends to eliminate the principal error encountered on our Oak Creek sack surveys. This added freedom in the census line to be followed is an important factor in many parts of the West where rough topography —ledges, impassable washes, etc.—many times render straight line courses impractical. There are still many reasons why it is desirable to follow straight census lines as nearly as possible, however. An obvious one is the added accuracy possible in determining the length of cenus lines. Another is that it prevents participants from following the easiest traveled routes which many times may yield unrepresentative samples.

Another advantage of King's method over Kelker's is that all observational distances are used in deriving the average sight distance, whereas, with Kelker's, observations beyond what is determined to be the effective width strip are not used. This factor becomes critical for the Kelker method when the number of observations on any one survey falls below 50. A greater number is desirable. Even with King's method, variation of sight distances for 315 dead deer found on surveys within the juniper-sagebrush type has been such that about 45 records are necessary to attain 10 per cent accuracy at 68 per cent confidence in determining the effective width of survey strip. The mean sight distance was 38.5 feet with a standard deviation of 25.9.

King's method has an advantage over the Lincoln Index in that an initial marking survey is not necessary. This pre-census marking survey requires about as much time and effort as the subsequent final survey so in effect it doubles the amount of work required by King's method.

We also feel that King's method has much to offer over the first strip sampling method mentioned in the introduction, *i.e.,* complete coverage of sample strips of predetermined width. Here the field man must decide, beforehand, from a knowledge of visibility conditions in the area to be sampled, the width strip on which he can expect to see all dead deer. Carcasses observed outside the strip must not be included in the sample results. Results from this method are likely to be on the conservative side for the reason that an occasional carcass within the strip may be missed. The observer can eliminate one source of error by leaving his line of travel in order to search through heavy brush cover, etc., which may fall within the survey strip but which cannot be adequately searched from the cruise line itself. However, if several individuals are conducting an organized survey it has been our observation that one will oftentimes pass through dense cover with inadequate searching on his strip rather than fall behind or hold up the group. On the other hand, should the individual restrict his strip to a width on which he can be certain of seeing all carcasses he will make inefficient use of his time, because only part of the observed carcasses can be used in the sample. Even with a restricted strip, optimism regarding one's ability to see all carcasses may exceed observational conditions. On the Oak Creek winter range, which has a rather heavy vegetative cover, 7 per cent of the carcasses were first seen at 10 feet or less by observers afoot and 4 per cent at 10 feet or less for horseback observers. Thus it is apparent that in similar cover types one would likely miss a few carcasses on a pre-determined strip as narrow as 30 feet (15 feet on either side of the observer) unless lateral searching is resorted to. By King's method we effectively covered a strip about two and one-half times 30 feet.

Sampling adequacy is an important consideration on any survey. The reader is referred to a paper by Geis (1953) for a discussion of methods for determining sampling adequacy for the strip census methods. The writers computed dead deer numbers for each 128 acres (one-fifth of a square mile) within individual surveys and for each of the seven surveys on the Oak Creek square mile yielding 35 sub-unit population values. This was about the smallest unit which could be used in which the frequency distribution of the population values still approximated the normal. The variance of these values indicated that 147 miles of cruise lines would be necessary on a survey to expect 10 per cent accuracy at 68 per cent confidence and four times this distance for 95 per cent confidence. The required distance would obviously vary with the density and distribution of dead deer and visibility conditions. Also, the required distance would be shorter when the area to be sampled is a finite one or it approaches the size of the sample (a survey strip 77.0 feet wide and 147 miles long is equivalent to 1372 acres). The reader is referred to a paper by Pechanec and Stewart (1940) for a method of determining sampling adequacy for a finite population as opposed to an infinite one.

Based on conditions prevailing on the Oak Creek square mile where a net average of 13.9 carcasses were found for each 20 miles of cruise line, we should expect to see 102.2 carcasses in 147 miles. The difference between the 45 carcass observation necessary to establish the width of survey strip with 10 per cent accuracy and 68 per cent confidence, as mentioned earlier, and the 102 carcasses required in deriving a population estimate of similar accuracy is attributable to variations in the distribution of dead deer upon the square mile.

In the use of King's method for censusing dead deer the writers would like to emphasize certain precautionary measures to be taken if reasonably accurate results are to be expected.

(1) Distractions such as looking for live deer and unnecessary conversation should be avoided.

(2) Participants should continually search for carcasses by looking from one side of the course to the other. The observer should be even more alert visually than when censusing live animals for he will receive no assists such as movements or sounds from the censused animals. Searching should be limited to a strip within which most carcasses can be expected to be seen.

(3) The survey courses should be run through the area to be sampled with the primary aim of obtaining representative samples. On most of the Utah winter deer range this can best be accomplished,

the writers believe, by running parallel survey lines diagonally across the topography from the lower edge of the winter range to the upper or vice versa. The courses to be followed should be systematically or randomly selected so as to avoid personal bias.

(4) Consideration should be given to sampling adequacy.

SUMMARY

The writers have tested five census methods (King's grouse census method, Lincoln Index, Kelker's belt transect method, Webb's snowshoe hare census method and Hayne's modification of King's method) by comparing population estimates derived from each with a known population of dead deer and of burlap sacks.

From the results the writers have concluded that Kelker's, King's and the Lincoln Index methods can be expected to give reliable results with adequate sampling and certain sampling precautions. Webb's and Hayne's methods, however, gave results significantly in excess of known population, indicating neither is adapted to the censusing of inanimate objects.

Of the five methods tested the writers favor King's for censusing dead deer for various reasons given in the text.

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DISCUSSION

MR. DON W. HAYNE (Michigan State College, East Lansing, Michigan): I want to thank Mr. Robinette for having discussed something I am personally interested in. In the first place, of course, the original work was discussed with the concept of different populations related to the behavior of the animals, and I think we have to remember that the concept relates to the behavior of the herd.

Offhand, I thnk the observers may have been lucky in finding the deer which are close to their paths, closer distances to themselves than one may expect. Now, I think this is the natural behavior of the observer in the field. He knows his path and he isn't going to bother to observe 200 feet ahead of him, but he will examine 200 feet on the side carefully. He knows he will pass the point ahead and he leaves it until he reaches it. That is my guess as to what may have happened here, to throw out apparently this concept of different populations with regard to side distances.

I think this is a very interesting study and well conceived. I think we need many more of them. All of these studies bring home to us the great difficulty of dealing with random things. It would appear offhand as he announced, the distributed objects at random over a space—but when one speculates on it, there turn out to be many practical difficulties. For example, if your previously conceived plan places a sack, by a tree, what rule follows? Do you put it on the side of the tree where the observer might see it or on the other side where he might never see it? That is an extreme case, but there are others which make this problem of random distribution very difficult.

MR. ROBINETTE: As I mentioned before, we selected two random numbers to determine the location of each sack within the block. And our trees are not very large out there, perhaps five or six inches in diameter would be the largest, so I don't think that would be any problem there. It is true that these tracks would be located at random in the sense that we think of locations of dead deer. However, going back to our results on the dead-deer surveys, especially the one at Meadow Creek, where we reported 30 per cent sampling of the area and saw around 80 dead deer, in doing that we had a good Kelkers's Method line constant index and King's Method, whereas Dr. Hayne's and Quinn's Method, are considerably greater.

Of course, that is not a known population, but the fact that we did get good agreement later in the sack surveys would indicate that perhaps we might get the same results on the dead deer surveys.

DR. WILLIAM L. WEBB (College of Forestry, State University of New York, Syracuse, New York): I would like to ask Mr. Robinette if he has found any evidence of bias in distribution of deer carcasses? You set up your sacks and place them at random. Are the deer carcasses found at random or, as in New York, concentrated in certain areas on certain types, particularly on warm south slopes, late in the winter?

MR. ROBINETTE: We found a rather general distribution of our dead deer on this square mile. But, in areas in Utah where we have very steep draws and steep slopes, especially if we have starvation losses, we are apt to find a heavier concentration of dead deer in the bottom of the draws. But, in the particular area we were working, we didn't have very wide extremes in elevation. It was a fairly general distribution.

CHANGES IN NORTHERN MICHIGAN FORESTS FROM BROWSING BY DEER

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The effects of browsing by deer have long been a controversial subject, and anyone who opens a discussion of this matter is very likely to find himself embroiled in an argument. Therefore this paper has been prepared in an atmosphere of trepidation. However, in spite of the personal hazards involved, it is hoped that it will elicit discussion.

By way of introduction let us review the environmental requirements of the white-tailed deer, the only species about which we shall speak in this paper. Basically its requirements are simple but, at the same time, exacting. To be successful a deer must have a supply of readily available food of good quality; it must have a safe place to rest, located not too far from the food supply, and sheltered from the elements, especially from snow, ice, and winter wind. It must, also, have suitable conditions for breeding and for rearing the young. If any one of these essentials is lacking in an area, there can be no deer herd there.

Seldom can all of these necessities be found in any single forest type. In northern Michigan the mixed conifer-hardwood swamp comes nearer to satisfying all of the requirements than any other single type. In contrast the pure-pine type and the pure-maple forest, of sapling size or larger, are virtually deer deserts.

Of all the necessities, food and shelter come first in importance. The other requirements are usually available in almost any area where these two things are present.

In different parts of the whitetail's range its needs are met by various vegetative types. In northern Michigan, where the winters are cold, shelter is especially essential and is best furnished by low-branching coniferous growth. Forest plantations are almost ideal until the lower branches die and the trunks become clear. White cedar, with branches to the ground, is even better, since it provides both food of good quality and shelter. But these desirable conditions are transitory. The trees grow up and ultimately become valueless for food and of decreasing value for shelter. A pine plantation ceases to provide shelter between 20 and 30 years of age. Cedar, if not heavily browsed, will be good for a 30-year period.

Food for deer in northern Michigan is provided in greatest quantity and quality in areas that have recently been logged. There both coniferous and broadleaved species are within ready reach of the deer and the animals can choose as they please.

Upswings of deer population in Michigan have invariably followed logging. The first upward surge followed pine logging and the subsequent repeated fires which prevented the re-establishment of the pines. When the fires were ultimately controlled these old pine cuttings were taken over by aspens, oaks, and on the better soils by mixed hardwoods, especially red and hard maple. Then the deer herd was provided with an abundance of food and responded accordingly. Cedar and other coniferous swamps provided them with winter shelter from which they could forage into adjacent cut-over lands.

However, the swamps were limited in size and were not always favorably located in reference to the upland cuttings. Winter concentrations of deer combined with logging operations in the swamps have greatly reduced the area of this winter cover. In many places forest plantings of pine have provided a substitute for the cut-over or browsed-out swamps, and now deer are yarding in pine plantations, especially those which have adjacent areas of hardwood cuttings.

In the western part of the Upper Peninsula where the specific observations reported in this paper were made, pine logging was finished about 1900. This was followed by a period characterized by repeated brush fires which prevented the development of trees on extensive areas. The general control of fire occurred between 1910 and 1920. Then cover improved and there followed an upsurge of the deer population in the pine lands.

On hardwood lands the increase came later. In 1935, when the University of Michigan forestry camp was moved to a hardwood area in Iron County, the deer population was abundant in local spots but in general was moderate. We may venture to guess that they averaged between eight to twelve animals per square mile.

By 1940, following increased hardwood cuttings, deer were definitely on the increase, but the effects of their browsing was not conspicuous. By 1947 the number of deer had mounted to the point where maple reproduction was in many places being retarded; and the reproduction of hemlock, yellow birch, and cedar was being eliminated. Since 1950 deer drives on sample areas indicate populations ranging from 25 to 50 deer per square mile. A comparison of browsing intensities indicate that some local areas are supporting even higher populations than the drives show; such concentrations occurring in those places where the animal's requirements are best met.

On some cut-over hardwood lands the young second-growth trees have now reached the stage when the trunks are clear of branches, and shade has eliminated most of the ground cover. There the deer find neither food nor shelter and therefore are practically nonexistent. Thus as vegetative cover changes on an area so does the deer population.

Clearly whitetails are dependent upon a combination of conditions that on any given area are transitory. Therefore management of the deer herd depends upon our success in keeping a satisfactory proportion of the range in young conifers with nearby recently cut-over lands occupied by shrubs and young trees of suitable food species. This can be accomplished silviculturally through successive logging operations, so spaced and arranged as to form a pattern that will provide adjacent food and cover continuously.

Trends in logging seem to be in the direction of small scattered operations. This procedure will favor the deer by producing a diversity of forest age classes. However, a diversity of age classes will be of no avail unless the species composition remains favorable, so that both food and shelter are always available for succeeding generations of the animals. It is essential that a desirable combination of woody species become established and maintained on cut-over lands if the deer herd is to continue in satisfactory numbers. Let us see if this is being accomplished.

In 1940 we began a study of the forest types of the western Upper Peninsula, including an investigation of forest reproduction following logging. The results indicate that an unfavorable situation for deer is developing, due largely to the influence of the animals themselves.

The following are the general facts observed. A large proportion of the hardwood lands cut-over prior to 1940 have grown to sapling size, the composition of species in those stands being, on the whole, not greatly different from that of the original forest, except that there seems to be little or no hemlock or cedar reproduction above the small seedling stage. We strongly suspect that the lack of these two species is the result of browsing. Without the hemlock in mixture, the deciduous hardwood lands are open to the full sweep of winter winds and therefore become uninhabitable for deer during that season.

In contrast on the more recently cut hardwood lands reproduction is more or less browsed and stunted. Some species appear to have been almost eliminated. For example, it is difficult to find a yellow birch, a cedar, or a hemlock under 10 years old, except for very small seedlings mostly of the current year. Hard maple is being browsed heavily in some places, more lightly in others. However, on most areas it will ultimately grow above reach of the deer, in spite of browsing. The trend thus seems to be toward a conversion of the mixed hardwood forest to almost pure hard maple. These hardwood lands that have been or are soon to be cut are extensive, occupying at least one third of the best deer range in the areas studied, and their conversion to maple will result in a serious reduction in the area suitable for winter use by these animals.

More specific information concerning the reproduction of forest trees and what is happening to these young trees were collected on sample plots.

Beginning in 1941, a series of plots was established under a variety of conditions. For the most part they were laid out in partially cut forests on a variety of soils. On each of these larger plots a series of small milacre plots, 6.6 feet square, were laid out, and on them the tree seedlings present were recorded. Between 1948 and 1952 the plots were re-examined to see what changes had occurred. The observations made on these plots indicate first, *what* tree reproduction may be expected following logging and, second, the effects of deer upon this reproduction. Space in this paper will not permit a full discussion of the results but in brief they are as follows.

The kind of reproduction varied with conditions but in all instances was diversified. Light-loving seedlings, such as aspen white birch, and the pines, became established most often in areas where more than one-half of the timber volume had been removed. The more shade tolerant trees, such as maples, balsam fir, and spruce, predominated on areas that were cut more lightly. On heavier soils, hard maple, yellow birch, and balsam fir seedlings were most numerous, whereas on lighter soils white birch, red maple, balsam fir and, to a lesser degree, spruce and pines were predominant. On seepage areas, where water was within a few feet of the surface, reproduction of practically every tree species of the locality was present in abundance wherever cutting reduced overhead shade. The observations showed clearly that a great variety of tree reproduction characterized every kind of area studied. Thus selective cuttings tend to retard succession and keep the forest suitable for deer.

The influence of the deer on the reproduction was evident on re-examining the plots seven to ten years later. The findings were surprising. In that time we should have expected the maples, birches, and other hardwoods to have attained a height of at least 10 to 15 feet and the conifers to be a foot or more in height. The conifers, except for hemlock and white cedar, which had disappeared from the plots. lived up to expectations, but not so with the hardwoods. On the 167 plots included in this series, yellow birch had either disappeared entirely or was represented only by newly established small seedlings; the number of red maple seedlings had increased but none had attained a height of 4 feet; hard maple had fared somewhat better and in a few cases had reached a height above reach of deer. This stunting of the hardwoods was undoubtedly due to browsing.

The most striking change was the surprising increase in the amount of balsam fir reproduction. On seepages the percentage of milacres stocked with balsam fir increased from 17 to 81 per cent. In mixed conifer-hardwood types on light soils, the blasam-stocked milacres increased during the period from 31 to 70 per cent; in uncut pole-size pine, from none to 50 per cent, and under mixed northern hardwoods on silt loam soils, from 13 to 80 per cent. Balsam fir provides good shelter for deer but little in the way of food. Mixed with other types it is good, but when it predominates over large areas it is not desirable.

On the heavier soils hard maple had almost invariably come to dominate the areas, and although other species were often present they were overtopped and becoming suppressed. Except for browsing effects, birch and other hardwoods would have been able to grow about as rapidly as the maple. Thus the deer, in one step are converting to undesirable tolerant forests the lands that logging could keep diversified.

The series of plots just discussed reprecsents the oldest set of observations that we have made, but even more striking information has come from some more recent work. For example in 1947 paired milacres were laid out in openings resulting from a partial cutting of a hemlock-hardwood stand. The objective of this experiment was to compare the reproduction following logging when mineral soil was exposed with comparable areas where the litter and humus layers were undisturbed.

One milacre of each pair was scalped down to mineral soil, the other was left untouched. This series of plots was re-examined in 1948, 1949, and again in 1952. As in most hardwood stands there was a considerable amount of hard maple reproduction already established at time of cutting. This advance reproduction combined with the influence of litter covering the soil, prevented invasion of most other species on the undisturbed plots.

On the 25 pairs in 1947, 22 of the unscalped milacres were stocked with hard maple, 16 with red maple, 10 with yellow birch. By 1952 red maple had disappeared from 10 of the 16 unscalped plots. The 10 yellow birches still were alive but had been severely browsed.

On the 25 scalped milacres, hard maple became established on 17 in 1948, a year after scalping, red maple on 14, yellow birch on 24, and hemlock on 12. In 1952 all of the hemlock seedlings were gone, but on 3 plots new one-year-old seedlings had replaced them. The number of milacres stocked with seedlings of other species changed little during the period.

From these results it seems clear that following logging of hardwood forests, the mixed forest, favorable for deer, will reproduce itself. But the deer begin at once to change the picture. On all of the 25 paired milacres browsing was heavy, with the result that the yellow birch averaged, after 7 years, less than 1 foot high. Similarly red maple, and, to a lesser degree, hard maple had been browsed. The advanced reproduction of hard maple which was present before logging on the undisturbed plots fared better because of its larger size and should ultimately grow above reach of the deer.

In order to discover what would happen if deer influence were excluded, exclosures were constructed in four of the openings where the paired milacre plots were located. Several of the pairs were enclosed within the fences. The exclosures were built in 1949, broken down by a windstorm in the fall of that year, and rebuilt in 1950. After four years of protection numerous hard maples, yellow birches and black cherry trees were higher than the 8-foot fence while similar species outside had gained little in height.

One surprising thing about the conditions in this forest is that to the casual observer they do not appear to be abnormal. A person walking through the area would be impressed with the abundance of reproduction and the quantities of food available to the deer. Even to some wildlife managers it would appear that this area has not reached the limit of its carrying capacity for deer, since there is available at present an abundance of food and shelter. To our notion this concept of "carrying capacity" is erroneous. The sound definition of this term should be based on the potentialities for continuous production. Actually the deer in this area have already so changed their environment that continuous maintenance of the population at present level will be impossible.

The undesirable situation just described would not have great significance if it were characteristic of only a small area, but similar conditions exist in most of the recently cutover hardwood lands in northern Michigan.

From the viewpoint of forest reproduction the situation, though not ideal, is in most places not actually disastrous. In the majority of places where the soil is heavy, hard maple reproduction will ultimately succeed in getting above reach of the deer. On the lighter soils balsam fir and other conifers will sooner or later take over. But from the wildlife management viewpoint, the picture is far from bright. We cannot have a satisfactory deer herd without shelter and an adjacent food supply. In the foreseeable future, if present trends continue this desirable combination of condition is almost certain to disappear from large areas, and with it will go a corresponding part of our deer herd.

At this point there is a strong temptation to advise what should be done about the situation. But that is not the objective of this paper. We have presented facts, let those responsible for the deer herd decide upon an action program.

DISCUSSION

MR. WILLIAM L. WEBB (Syracuse, New York): I would like not to comment on Mr. Graham's paper, but add another phase or facet to the picture on the hunting and wildlife in the Adirondacks. We have two exclosures, each two and a half acres, which were established 14 growing seasons ago. These exclosures are in mature hardwood stands. There is considerable spruce, some hemlock with an average diameter of the hardwoods up around two feet. The stands were logged a good many years back, close to a hundred years now. But, there is no evidence of that very early logging.

In a 15,000-acre area closed to hunting, the exclosures are near the center, so probably they are little affected by surrounding hunting. I wish I could take you there and be able to take a fence down before you got there; you couldn't tell where the fence had been. I believe 99.9 of us here would walk straight through the exclosure area and never recognize it as an area protected for 14 years from deer.

I think the picture Mr. Graham has presented is undoubtedly an accurate one for Michigan. I suppose what I am trying to say is, use a little caution in going into an area and finding what appears to be deer effect on forests and assuming it is deer that caused it. These stands are obviously overgrown. There is no question about it to the trained observer, and there is no question in my mind about the results of these exclosures. Hardwoods are abundant, but under a foot in height. The witchhobble, which is our standard deer winter food, doesn't look like it has a chance. The same condition prevails after 14 years of being inside the exclosure, so the only conclusion you can come to is that the deer had no effect.

The difference in height, diameter and growth of hardwood species inside and outside the exclosure is so slight, you can't see it. We can just begin to measure it after 14 seasons. If I remember the figures right, the hard maple is an inch and a half higher inside the enclosure than out, which makes the total average height of the hard maple reproduction about eight inches.

MR. GRAHAM: I would like to comment on this. Obviously the deer exclosure that was referred to was in a place where you would never get any forest reproduction growing up above a few feet in height under any circumstancs, and the fact you don't find reproduction in this sort of an enclosure is not at all surprising. We have hardwood stands in the upper part of Michigan, similar to the ones described. I am thinking specifically of the area around Marquette, and without any excess of deer at all, the reproduction is about as described by Mr. Webb; and it will stay that way for almost as long as the trees are there.

The situation that I am referring to is not in the mature stands of hardwood that are uncut, but in the stands that have been logged over, some of them clear cut, some of them partially cut. There you would expect to get reproduction, and I am afraid that a great many deer exclosures have been laid out by wildlife managers in areas where you couldn't expect to get reproduction under any circumstances. The only place where you can determine whether or not the deer are having any material effect is in these areas where nature would be able to bring about the establishment of trees and give them a chance to grow. That is a situation I was trying to describe.

MR. FRANK BARICK (North Carolina Wildlife Resources Commission, Raleigh, North Carolina): This is a very interesting subject to us in North Carolina, too. I have in mind a particular tract of land which has been cut over in the western part of the state. It is one of those areas that is usually referred to as hardwood. It was a poplar grove and the area that was cut over had a very large amount of large hemlock. It was virtually clear cut.

Several years after the cut, there were quite a few complaints as to what the deer had done to the reproduction in Lost Cove, and it was quite apparent to people walking the trails, and incidentally from the sawmill receipts, that the deer had done considerable damage to reproduction, especially of yellow poplar. The yellow poplar along the trails was drastically browsed back. However, if one examined the situation a little off these trails, the situation was entirely different. We ran a series of lines through these areas of reproduction, and we found through counts—seven or eight years after the loggings—the trees in most cases were 5 to 8 feet high. In some cases the yellow poplar reproduction was an inch or two or three inches in diameter, and we found counts as high as 3,000 trees per acre reproduction after logging, in spite of the extremely heavy browsing.

This had been pointed out to us in the wildlife repartment as being the very height of damage that could be done as far as reproduction of yellow poplar. We found actually an average—we did this about three years ago, and my memory may be a little faulty—we found 800 well-established yellow poplars per acre.

Now, that to my mind was very revealing under these situations anyway. We came to the conclusion that the cutting was intensely done and the source of reproduction adequate so that we could bring through a very good stand, a very desirable hardwood stand, in spite of an extremely heavy deer population and deer browsing.

DISCUSSION LEADER DASMANN: Did you have any exclosures in this area for comparison?

MR. BARICK: No. We were just comparing the evidence of deer browsing along the trails. All along the trails and roads and the edges of the clearings were browsed. You could see it, and that, I believe was the reason for the criticism of the deer. But, the minute you go off the trails you could hardly push your way through the dense stand of reproduction.

MR. RALPH H. ALLEN, JR. (Alabama Department of Conservation, Montgomery, Alabama): I would like to ask Mr. Graham if he has done anything in controlled burning in holding up stands like that?

MR. DAVENPORT (Michigan): We have carried on numerous controlled burning projects. However, our projects have been designed primarily to hold operations, rather than to create new ones. We find when we get into the stands of heavy young timber, that we can't burn them safely at a time of year when we can get control or eliminate the vegetative types that are there. Consequently, our efforts have been limited mostly to spring burns and a few fall burns and attempts to burn heavy stands of vegetation have not been too satisfactory. We, I think, look upon controlled burning right now with a little less favor than we did a few years ago. We realize it is a potent weapon and with practical limitations, controlled burning is very helpful.

SOME OBSERVATIONS ON GAME AND GAME RANGE TREND IN SOUTHERN KENYA, BRITISH EAST AFRICA

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During the summer of 1953, two trips to observe game range were made in southern Kenya. The purpose of this paper is to discuss game and game range trends as observed in the Scattered Tree Grassland (*Acacia-Themeda*) habitat, both within and outside of tsetse fly zones.

For many years there have been reports on game range conditions in Africa which seemed to conflict with principles of good range management. These reports give rise to the question: What are the existing conditions and factors surrounding game range productivity which permit maintenance of great herds of plains game without corresponding damage to game range? In addition, reports of heavy damage to grasslands caused by domestic livestock were nullified by claims that the ranges recovered rapidly during rainy seasons.

Some of the more productive plains game habitat is found in the (*Acacia-Themeda*) grassland habitat described by Edwards and Bogdan (1951). This habitat is one of the most favored and photogenic grassland settings of African hunting safari. It is a beautiful, soft, rolling savannah. Parts of it are in near pristine condition because of large areas which naturally exclude use of domestic livestock due to the presence of tsetse flies, which transmit Trypanosomiasis, or sleeping sickness. Vegetation of tsetse fly zones has changed little since the Pleistocene, and only as influenced by natural factors. Collectively, these zones protect about ten per cent of Kenya's original game habitat from the impact of native livestock. These restricted zones act as ecological sanctuaries, and provide the most unique spectacle of plains game remaining outside of African national parks. They have the feel of ancient wilderness and are avoided by the Masai and other native pastoral people.

Through the courtesy of Mr. Wm. S. Hale and Sir James Kirkpatrick of the Kenya Game Department, arrangements were made to see range conditions in one of the tsetse fly zones with Major E. W. Temple-Borham, M. C., Game Ranger, Narok. On this trip the writer was accompanied also by Mr. R. R. Waterer, Chief Forest Conservator of Kenya. The second trip was made into a tsetse fly-free area with Mr. Phillip Kellar of the Masai Grazing Scheme and Captain Dennis Lapharo, Game Ranger, Kajiado District.

Herds of zebra, topi, wildebeest, kongoni and species of smaller antelope are very abundant within tsetse fly zones of the Narok District. Maintenance of good range and soil conditions which prevail under the apparent heavy rates of big-game stocking surely must puzzle many trained observers. On the basis of criteria used in judging range condition on public lands of western states, these ranges were considered well utilized, but in good condition. Little evidence of soil or range deterioration was observed along a 140-mile transect within a tsetse fly zone.

The reasons why this condition exists, in the opinion of the writer, are a combination of naturally favorable factors, These include non-use by domestic livestock, good soils with soils at an easy angle of repose, partial control of big game productivity by disease and predation, natural deferred and rotated grazing use of grasslands or range resting periods brought about by two growing seasons, and game migrations into Tanganyika and return. The natural ability of the major grass species (*Themeda triandra*) to withstand fire and replace itself and to withstand occasional heavy grazing use also lends stability to the range lands.

The grass species, *Themeda triandra,* forms a fire subclimax grassland in the *Acacia-Themeda* habitat. Where this grass produces sufficient density to form heavy fuels, fires during the dry season eliminate occasional colonies of small acacias which, in places, invade the grassland. Thus, large open areas of grassland are perpetuated.

Predator-prey relationships normally are tight and tense. Predator populations have great depth of species and exert accordian-like pressures made up successionally of lesser carnivore abilities. There can be little doubt that predation is partially effective in controlling productivity of many plains game species, yet game is abundant. Lion and leopard are protected throughout the Narok District, not especially to aid in control of game surpluses as related to range, but to restore lion as a part of the fauna, and as a huntable big game species. The Kenya Game Department is entirely sound in this policy since it is most important to range preservation. and to the game itself. This viewpoint is supported by Calahane (1952) in his report on wildlife resources and conditions as observed in Africa in 1950.

Under the protection of Game Ranger E. W. Temple-Borham, lion have increased in the Narok District from 15 in 1945 to 300 in 1953. It is estimated that this present lion population takes 10,000 head of plains game each year on this district alone.

Plains game in the Narok district is seldom hunted by natives. Only about 50 parties of white foreign hunters hunt big game in all of Kenya each year. Local white hunters in the past have made serious reductions of the more edible species of large antelope. Under present controls and reduced bag limits, selective hunting for food is no longer, if it ever was, effective as a means of maintaining game herds in balance with range productivity.

The tsetse fly zone of the Narok district crosses the Kenya border and extends more than 100 miles down into Tanganyika. Near this border a government project is now under way to clear more of the bush as a means of eliminating tsetse fly. Ecologically, this means an almost shade-free grassland. The purpose of this work is to graze greater numbers of Masai cattle and goats. This project cannot be considered sound from either a game and game range standpoint, or economically sound in the long run unless control of numbers of Masai livestock using the cleared land is established in unison with the clearing process. Control of Masai livestock use is not practiced. The end result of this clearing work will be a trend toward desert conditions, more bare soil permitting increased wind and water erosion of disturbed soils and less cattle and game grazing capacity. The natives tribes will for a short time have more pasture, but in a few years must again agitate for new clearings. Who wins if the range resource is destroyed?

Extensive areas of Scattered Tree Grassland also occur in southern Kenya on the Kajiado district which are naturally free from tsetse fly. Much of this habitat has been overgrazed by Masai livestock and range productivity has been broadly and severely reduced. Moreover, much of this grassland has reverted to unpalatable species. According to Edwards and Bogdan (1951), annual burning of the desirable *Themeda triandra* grassland, when combined with heavy grazing use, effects a retrogressive trend toward unpalatable species, especially species of *Pennisetum*. In the Kajiado district, the principal species observed in this retrogressive succession was *Pennisetum massaicum*. Apparently when stands of *Themeda triandra* are greatly reduced, fire cannot run in them with the same former intensity. Thus *Pennisetum massaicum,* which is unpalatable, but also is sensitive to fire, may be successfully established on overgrazed range. Here the *Themeda triandra* fire subclimax no longer exists. In its place is a rather ragged, eroded, beaten up grassland association having a moth-eaten aspect. Sparse colonies of *Pennisetum massaicum* occur, with much bare soil or useless annuals growing between colonies for short periods following rainy seasons.

Fire, where it can occur on these overgrazed ranges, also brings about a trend toward a subclimax of fire resistant unpalatable shrubs, especially along stream bottoms within the *Acacia-Themeda* habitat.

Here, as observed by the writer, heavy browsing of palatable shrubs apparently aids dominance of unpalatable fire-resistant shrubs in the association.

Although the *Acacia-Themeda* habitat of southern Kenya, except for tsetse fly zones, is rapidly deteriorating as game habitat, game still persists. Because of its good soils and 25 to 35 inches of annual rainfall, it has an excellent range potential. Much of the range land now denuded would recover under intelligent range management practice, and without costly expenditures for range restoration by seedings, fencing and terracing.

Few peoples of the world have been succesful, including ourselves, in continuing a sustained pastoral economy on arid grasslands. The job to be accomplished in Kenya is especially difficult because of tribal antipathy to change of any kind, but especially to those involving social religious customs. Grass is sacred to the Masai. They believe that God gave them all of the cattle. Therefore, they do not believe that cattle, their gift of God, could injure the sacred grass. Change in land use, or of livestock use, is beyond their understanding. Because of present political difficulties in Kenya, land use reform for the general long range welfare of all Kenya people is probably a long way off. Any move in this direction by the government of Kenya should have the aid of all the people of the world who are interested in its priceless wilderness and its living relics of geological times.

SUMMARY

Tsetse fly zones offer opportunity for measurement of condition and trend on range used by big game alone. Range conditions as determined in tsetse fly zones may be compared with ranges naturally free from tsetse fly which have been under dual use by domestic livestock and big game for many years. In addition, a third condition exists, that of range which has been recently cleared of bush to control tsetse fly. These latter areas offer places for initiating studies of range on which use by domestic livestock is a factor newly added to the environment.

Plains game habitats of southern Kenya within tsetse fly zones are in very good conditions; basic food and cover resources are intact. The present policy of the Kenya Game Department in protecting and maintaining populations of large carnivores which limit plains game productivity is entirely sound.

Much of the game range habitat found outside of tsetse fly zones or national parks is being rapidly reduced in forage productivity through extreme overuse by cattle and goats. Temporary rejuvenation of game

ranges during rainy seasons is very misleading. Range retrogression includes heavy soil erosion, replacement of valuable forage species by unpalatable forage species, including short-lived annuals which show up well after rains.

Destruction of the basic food resource of the game habitat is considered a far more important factor in game reduction than killing of game by natives or by sport shooting.

People of Kenya who are interested in game and game range believe that tsetse fly control, if successful, will mean almost complete destruction of the remaining original plains game habitat.

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TECHNICAL SESSIONS

Wednesday Morning—March 10

Chairman: Hayden W. Olds
Director, Tennessee Division of Game and Fish, Nashville. Tennessee

Discussion Leader: R. W. Eschmeyer
Executive Vice-President, Sport Fishing Institute, Washington, D. C.

CONSERVATION EDUCATION

WHAT IS THE ADMINISTRATOR'S RESPONSIBILITY FOR CONSERVATION EDUCATION?

Hayden W. Olds

As director of a relatively young, husky, and still growing State Game and Fish Commission, I would naturally approach the subject to be discussed from a viewpoint of a wildlife administrator. It is frequently necessary to face situation which seriously threaten continued public support. Situation of this nature develop because the public has not received facts by which to judge the situation or perhaps is not conditioned to its acceptance. Daily, we are required to convince or perhaps educate a disgruntled citizen that the purchase of a hunting license does not convey the right of trespass or provide an open season on domestic stock; that the fish and wildlife resources of the state belong to all the people, therefore, a proper license is required; that the right of a fisheries biologist to use an electrical device or net is not extended to the general public; that a conservation officer might do a better job because of what he knows and not because of whom he knows; that a fox does eat a few other items than farm-grown chickens; that each newly discovered exotic species is not the panacea for restoring game populations to the good old days; or that the smartly uniformed and trained conservation officer seen daily might be just the answer for which the chairman of the program committee for PTA, garden club, or service club, is seeking. In considering the subject titles to be discussed by the distinguished panel members, the balance is good. It appears that some will state problems related to conservation information, and others are prepared to offer solutions.

In commercial advertising, the would-be customer is bombarded from all sides, and modesty seemingly has no place. The manufacturer tells the world in a positive manner that his product, because of research and production techniques, is superior, and all competing items are poor imitations. This is smart advertising, but the same approach by a governmental agency could readily be tagged as propaganda.

Those who work with the renewable resources know the importance of conservation education and the dispensing of conservation information. The reworking of technical information into such forms that it can be readily understoond by the average person is not propaganda. The promotion of proven techniques is not an offer of false hope. A very realistic problem exists when these and similar concepts are not understood by legislators, educators, newspaper editors, civic leaders and others who, because of the positions they hold and if adequately informed, could be disciples of conversion rather than aversion.

Each administrator in the field of wildlife conservation sooner or later recognizes the need of an educational program. There is at present a considerable uniformity of approach, as evidenced by the use of such common media as magazines, news releases, technical and semi-technical bulletins, public speaking, movies, radio, television, advertising posters, etc. In giving consideration to diversity and intensity of approach to the problem, the wildlife administrator will find it necessary to ponder many questions. The following questions are believed representative:

1. Assuming funds are available, what would constitute a model game and fish conservation educational staff? What training would be required of employees and to what responsibilities would they be assigned?

2. What percentage of the total budget available to a game and fish department should be ear-marked for conservation education and information?

3. On limited budgets, what type of approach to a conservation education program will give greatest returns?

4. Should conservation education and information responsibilities be clearly defined prerogatives of a specially trained group?

5. If all personnel are expected to dispense public information and

perform phases of educational work, what in-service training and other methods of informing personnel should be instituted?

6. To what extent is conservation education a responsibility of a game and fish department in view of the fact that every state has a department of education or public instruction?

7. What is the best approach to securing worthwhile cooperation with the Agricultural Extension Service and State Department of Education, thereby to best insure conservation education being incorporated into agricultural projects and public educational programs?

8. To what extent should a game and fish department finance, staff, and otherwise encourage conservation education workshops in cooperation with teacher-training institutions of higher learning?

9. To what extent should game and fish departments go into developing interest and providing printed reference material and adult leadership on wildlife conservation to presently established youth organizations, such as 4-H Clubs, Future Farmers of America, Boy and Girl Scouts, etc?

10. Can game and fish departments justify the sponsorship and full financial responsibility for youth organizations of the type commonly referred to as junior rangers?

11. How can administrators evaluate relative benefits of public speaking, radio programs, motion pictures, television, exhibits, news releases, conservation magazines, bulletins and other printed materials?

12. How can the administrator best achieve and utilize cooperative services of writers of outdoor newspaper columns and magazines?

13. How can a game and fish department utilize and encourage the abilities, enthusiasm, and cash contributions of organized sportsmen in conservation education activities?

14. To what extent should the state program be extended or modified to include the many excellent ideas of federal agencies, national associations, and organizations dedicated to the conservation of one or perhaps several of the natural resources or the help now offered by many of the nation's great industrial organizations?

15. To what extent should game and fish departments solicit assistance of organizations whose major interest may not be conservation education but many of whose members are interested, that is federations of women's clubs, garden clubs, civic groups, etc.? What is the best approach to attain assistance?

16. How can the administrator best present a desired educational program on a specific subject to a local community or group? Are public hearings, open forums, special news releases, etc. the answers?

17. How can the administrator best present a desired educational program on a specific subject to widely scattered members of a particular group, such as state legislators?

The questions, as read, are not presented in an order of importance and may not adequately cover the entire field, but I do believe that if administrators had proper answers to all questions, as read, and the funds necessary for a follow-through, more sympathetic understanding and support of current programs would result.

THE ADMINISTRATOR'S RESPONSIBILITY IN AIDS TO TEACHING CONSERVATION

E. LAURENCE PALMER

National Wildlife Federation; American Nature Association, Ithaca, New York

Our administrator chairman has set an excellent example in defining the administrator's responsibility in teaching conservation by giving us in the panel a number of specific desirable goals that might be reached. Obviously no one of us can answer all the questions he has raised. I shall not attempt to do so.

Instead of speaking in abstractions, and to illustrate my points, I intend to use specific examples showing where in my judgment conservation education may have succeeded or failed because of the influence of the administrators.

In the fall of 1938, I collected some 2,000 names of rural New York youngsters, two to a school, whose teachers indicated that they would like to be designated as junior conservationists for their neighborhood. I went to our conservation commissioner, Lithgow Osborne and asked if he could not issue postcard certificates issued over his signature to these interested youngsters. I was told that there was no money for such service and it was felt that the Conservation Department was adequately satisfying its obligation to conservation education by issuing news releases.

Since that time a whole new philosophy in conservation has developed in my home state. We now have a vigorous conservation education division publishing an excellent journal; we provide assistance to teachers in service and in training, enlisting the cooperation of administrators and generally we are doing an excellent job.

A few years ago the department attempted to approach the whole problem through enlisting the support of the strategically situated heads of our teacher training schools. These men were brought together in a camp situation, induced to shed any stuffed shirts in their wardrobe and they came through with a program that promised to "go to town." Backed by the Department of Education, the state colleges of forestry and agriculture, the America Nature Association and the Conservation Foundation, we got down to work. A graduate student went to work integrating the efforts of all these schools. He came through with a respresentative program supported by all groups and was about to get the program into print when the able director of curriculum from the State Education Department was moved to a higher position. His place was taken by another. Since that time, the whole program has gone by the board except for the carry-over in the teacher colleges.

A state conservation department can of course evolve a program but it is futile unless it can become a part of the curriculum the state supports. Here we had a fine example of two state agencies working first in harmony and then in disharmony. Who had the responsibility to maintain this harmony? We will get nowhere until it is restored, and at present it looks hopeless.

Last summer I experienced one of the finest examples of a number of administrators working in harmony towards a common goal in conservation education. I was delegated by the National Wildlife Federation to work with the Boy Scouts on their Jamboree. Ted Pettit of the Scout Headquarters staff gave me major responsibility in the conservation program. I wish I could tell you the details but I cannot.

We had no funds with which to work. All we had was enthusiasm and faith in a project. We provided 50,000 scouts and scout leaders each with a pound of printed material presenting the story of conservation as seen by leaders in soil conservation, wildlife and forestry. We gave them instruction on the ground outdoors for from one hour to an hour and a half and in one week processed 28,000 boys who are now scattered over the country. They are a nucleus for the scouts' good turn project for 1954 which begins next week. It was sanctioned by the President of the United States. Its goal is to improve youngsters by helping them improve their environment.

In this scout project we had support of federal, state and private organizations. Without it we would have failed. C. W. Mattison of the Forest Service, Bert Robinson of the Soil Conservation Service, Jack Culbreath of the Fish and Wildlife Service supported superbly by Seth Gordon of the California Department of Fish and Game and by Fair Griffin and Don Lewis, representing West Coast soil conservation and forestry, made the program function. The Long Beach

State College, through its president Victor Peterson, a committee from the college headed by Richard Miller and a quartette of graduate students supported by a grant from the National Wildlife Federation solved many discouraging problems that arose. Members of the West Coast units of the National Wildlife Federation and the Izaak Walton League provided badly needed manpower in servicing sometimes as many as 2,000 youngsters simultaneously. When the first contingent of boys began to go through the program that morning in sunny California, I offered up a silent prayer of thanks to everyone who had helped make the program go. I had taken two aspirins with me to use in an emergency but when the program began to click I threw them away.

Now here is where you administrators come into this picture. The National Headquarters of the Boy Scouts of America has prepared adequate printed material to help these boys in your home communities make their surroundings better. We need your cooperation from the time of the ''kick-off'' next week until the whistle sounds next fall. See Ted Pettit or me or your local council to see where you can help. Then get busy and do as well or better than did the Jamboree staff, if you can.

Another example of cooperation between administrators might be illustrated by the joint project involving the American Nature Association and the National Association of Biology Teachers. Since 1925 the American Nature Association has been, among other things, sponsoring graduate fellowships on an average of $2,000 a year. Through this modest sustained support some 50 able young men and women have been trained to the Ph.D. level and are now strategically placed in teacher training institutions from coast to coast. Each of these fellows traveled extensively and met workers in the field. They evolved their philosophy from the successes and failures they had the opportunity to observe.

With a grant of $10,000 from the American Nature Association to the National Association of Biology Teachers and administered by one of these fellows, a manuscript for a book on teaching conservation has been prepared by classroom teachers across the continent. It will be published this spring or summer. In part as a result of the success of this project the National Research Council has established a committee on biological education with a representative of this project in its membership. This should result in an excellent exchange between classroom teachers nad academic leaders working in the higher echelons of biologic science. It is doubtful if much of this would have happened without the intelligent administration of the resources available to the American Nature Association.

Further examples of the far-reaching influence of administrators might be found in the activities of the National Wildlife Federation. Its identity with the scout program has already been mentioned. But over the years since initiation of its stamp program, the Federation has exerted much influence in conservation education. Through funds raised by the stamp program it has sponsored workshops for teachers and sportsmen in many states and has supported fellowships in colleges and universities over a wide area. During the last three years its energies have been devoted largely in education to helping integrate the effort of all organizations interested in conservation education. The record of that activity cannot be here reviewed. However, with that integration better established the Federation is this spring launching a new series of publications designed to help all organizations advance the conservation idea.

These publications are of two types. One, the "Let's Do Something" series, is based on reports of things that have actually been done by outdoor folks to improve the environment in which they live for the good of wild things. Copies of the first three of these dealing with brush shelters for fish, V-dams, and log dams are distributed at this time. Your reaction to them is solicited.

These units are prepared by Dr. John Bulger who with the backing of fellowship money from the Federation traveled across the continent seeing what men had done and could do to make their home area a better place in which to live. The idea is that the proposals are not imaginary but practical. What one ordinary man can do in one place another common man can do in another. This habit of doing something for the betterment of things in which we are interested should be acceptable conservation except possibly to the academicians who prefer to be provided with a set of principles or a book that they can learn and repeat as evidence of their mastery and leadership in the conservation field.

The "Let's Do Something" series is accompanied by the Federation's "Approaches" series.

Cooperating with the Federation in the publication and distribution of literature as just outlined is the Outboard Boating Club of America. With a grant of $10,000 they are, through the Federation, supporting units designed for improving conditions for fishes, with the preparation of significant supplementary sensory aids for these units and with the support of some basic research in the fisheries field. A further grant for the support of researches made to the Sports Fishing Institute and administered by our panel chairman may be elaborated by him.

Since in the majority of cases it is the administrator who "calls the shots'' and decides whether a conservation education project will get support it is important that administrators be well trained and informed. It seems to your speaker that any program worthy of support must be down to earth, must be practical rather than essentially academic, must be interesting to the participants and must result not only in the getting and dissemination of knowledge but in its application by as many persons as possible in as many places as possible. It must result in the establishment of sound habits of behavior, some of which may be foreign to the orthodox school teacher. For this reason practical conservation administrators have a right and an obligation to insist that they be in the picture of the major state and national conservation education programs.

Possibly we can draw some help from what has happened in the field of science education in the last 20 years. In 1931, the National Society for the Study of Education published its 31st yearbook designed to help advance the cause of science education. It recommended a program based primarily on a mastery of generalizations. Great improvement in science education was predicted. In 1947 the Society published its 46th yearbook giving additional defense to the same philosophy and prepared in part by those who prepared the earlier book. We were promised great strides in science education by these books.

I do not pretend to be able to evaluate the influence of these yearbooks on science education but I do offer you a quotation from a report of a Summer Conference on Science Education held at Harvard University the summer of 1953. It purports to present the trends in science education since 1930. It was prepared in part by some identified with the yearbooks. Rather than offer my own views on the subject I elect to quote directly from the Harvard report and let you draw your own conclusions.

On page 7 of the Harvard report we read: ''General Science and Biology are the only sciences experienced by a large fraction of our contemporary high school population. Chemistry or Physics is taken by a much smaller group of pupils; in these courses enrollments have not expanded appreciably since 1930.'' It was in 1932 that the 31st yearbook promised us so much. On page 12 of the Harvard report we find a graph showing a marked decline in the number of college graduates prepared to teach mathematics, biology, general science, chemistry and physics for the years 1949-53. This period immediately follows the appearance of the 46th yearbook.

I do not claim that these trends are due to the philosophy enunciated in these yearbooks. In view of the Harvard report I would find it difficult to support the idea that these yearbooks and the philosophy they have followed have contributed to more effective science teaching. Certainly no one would deny that in the period from 1930 to the present there has been great progress in the teaching of conservation. I rather think that this may be due to the practical down-to-earth program that has usually been identified with conservation education. I hope that we do not depart from that trend. We need help on conservation education in urban areas. We need help on adult conservation education. We need much help but I think that we are going in the right direction and that we will make greater progress as the years go by.

I learned recently that someone has said that it is encouraging that I was leaving the science education field for conservation education since now my areas of influence could become more progressive. If I must interpret the Harvard report correctly I am compelled to feel that maybe my critic's definition of what is progressive may be found in the last sentence of Stephen Leacock's classic story ''Guido, the Gimlet of Ghent'' which appears in his estimable *Nonsense Novels.* He describes his heroes of the tale as ''hustling down the spirals as fast as they could crawl, hind end uppermost.'' Maybe that is progress. I wouldn't know.

INDUSTRIAL INTERESTS IN CONSERVATION

KENNETH E. HUDDLESTON
Farm Equipment Institute, Chicago, Illinois

I appreciate the opportunity your Program Committee has given me this morning to be here and discuss a few principles of conservation education—a subject in which all of us are interested.

Before commenting, however, on the panel topic for this discussion, I would first like to review briefly the interest of industry—and namely the farm equipment industry—in soil, water and wildlife conservation.

As all of us know, in the past few decades industrial leaders have taken an enlightened interestd in resource conservation. These industrialists well realize that the success of much of industry depends on how well we conserve and how diligently we develop and use these resources. In agriculture, the financial welfare of the farmer depends on the productivity of his land and how well he utilizes that productivity. The base of productivity is conservation of resources. An acre is dead when it has lost its productive soil. An eroded acre is not conducive to wildlife development. Industry is extremely conscious that dead acres do not support a farmer. And dead acres do not support sales—including farm equipment sales.

Industry's support of conservation ativities is just good business management. But also, as the official of one farm equipment company has said. "we are against depletion of our natural resource assets as a matter of principle—and principles are daily routine with us, quite apart from the dollar sign."

Industry also recognizes that a happy worker is one of the most important cogs in sustained economic industrial production. Abundant wildlife offers endless recreational opportunities for all of us—and makes it opportune for the worker and his family to get away from the hurried metropolitan living, the din of the city, and take new stock of the really important things in our everday life.

The Farm Equipment Institute, which is a trade association representing manufacturers of farm equipment, has long devoted much energy in emphasizing the importance of conservation to all audiences. It has a specific conservation committee, and a well defined conservation program which both manufacturers and farm equipment dealers are helping to carry out. Individual farm equipment companies have published vast amounts of the informational literature, booklets, and have made many movies to help sell the conservation story. I am sure all of you are acquainted with these, so I will not waste your time to review them.

A couple of years ago the farm equipment industry, in cooperation with the dealers' association, launched the "Farm Equipment Dealer-Soil Conservation District Program," the end purpose of which was to encourage more farmers and ranchers to practice a well-rounded program of resource conservation. This attention was given to Soil Conservation Districts because these Districts offered a local unit of an aggressive conservation program which farm equipment dealers could support and from which they could obtain help in reaching farmers to encourage their greater use of conservation practices. Likewise, the program encouraged greater cooperation by the local farm equipment dealer with all conservation groups, including county agents, vo-ag teachers, wildlife conservation officers and citizens' conservation groups.

Although it is seldom mentioned, farm equipment design development in the past two decades has contributed greatly to wildlife growth. Innumerable agricultural soil conservation practices which benefit wildlife would not be as widely used today had not modern farm machinery facilitated their application. The hydraulic systems on tractors enable a farmer to lift his equipment easily over and protect grassed waterways which offer a cover for wildlife the year round.

The construction of farm ponds made economically possible by the flexibility and power of modern farm machinery also benefits wildlife. The blading in of gullies and planting them to permanent vegetation or trees also helps. And the tractor does make a lot more noise than "Old Ned" did. This gives a warning to wildlife and enables it to get out of an area much better than when horse-drawn equipment was used. The flushing bar also exists as an attachment for modern machinery.

I have briefly reviewed these items to indicate that although there are no great big signs hanging in front of the farm equipment manufacturer's place of business or in front of the dealer's establishment saying that we are dedicated to resource conservation, sincere interest is there.

And now, more specifically to our discussion topic, "What Is the Administrator's Responsibility in Conservation Education?" The word "education" is an important word and thought to us. It indicates a positive approach and an aggressive way of doing things. It is in direct contrast to the ideologies which all of us dislike—ideologies which attempt to attain by mandate and dictation with a police state to carry out enforcement.

Chairman Olds, in reviewing the topic for discussion, has indeed proposed a sizable number of quite Gargantuan questions and problems. Unfortunately, many of them are questions which only the individual administrator can answer. They must be evaluated with other administrative problems that are bound to exist.

So possibly, if I can make a contribution to your Conference, it can best be made by discussing a few observations in the light of education that I feel must be recognized for the successful administation of a wildlife conservation program.

Let us first analyze "What IS Conservation Education?" Here is why I raise the question. Many times there is a tendency to treat conservation education as a separate entity of the over-all conservation program. And this doesn't happen only in conservation. It happens very often in various industries. Many look on "education" as being a unit of action as bulletin writing, news release preparation, editing. An administrator's responsibility in conservation education is far greater than its treatment as a separate entity. Speeches and news releases are only tools of conservation education—just a few of those we can use to put our program or its message across to the consumer or recipient we have in mind.

Conservation education is actually involved in just about every job every employee of your conservation departments undertake. It is involved when someone writes a letter to your department or phones you. It is present when a sportsman purchases a fishing or hunting license—or it should be. It should be uppermost in the mind of the conservation officer or game warden when he explains to a hunter that he is violating a conservation law. Conservation education, after all, is an attitude, a way of doing things—that can well be the difference between a conservation program being successful or unsuccessful. Therefore, can you afford to treat conservation education as a separate unit? Should it not be, instead, a guiding principle for your complete program?

There are many educational tools that can be used to explain and help sell a conservation program in your states. Chairman Olds named a few of them: News releases, magazine articles, prepared speeches. A highly specialized industrial program would have an advertising, public relations or information department preparing such material. Some of these tools can be quite helpful—and a well-rounded conservation program should include their preparation.

Many times we hear charges that these educational tools are being prepared to "propagandize" for more appropriations for a governmental department, or for some other reason. We have to admit that these tools can be developed and used for such purposes. And many times there is only a hair's breadth between developing a news release to sincerely tell a story or to "propagandize." The stigma is there, nevertheless. What can the administrator do about it?

I have known cases, and I am sure that you know of cases too, where an administrator uses this situation to excuse himself and completely ignore his responsibility to develop and use badly needed educational tools. Let me ask, "How can you carry out a program by educational methods without developing and using educational tools?"

Many times I've wondered why public administrators do not make greater use of semi-official advisory committees in situations similar to these. Such committees should be made up of irreproachable representatives from industry and other groups. Such a committee to advise an administrator on principles of conservation education and the development of educational tools, it seems to me, is a prerequisite for developing and carrying out a good conservation program.

I have heard administrators say, too, that industry and other groups will not furnish manpower for such volunteer work. Let me say that the more progressive programs of a public responsibility nature today depend on such committees. And likewise in industry, many industries have such advisory committees made up of representatives from the subject field in question.

I want to emphasize, however, that the preparation of stock speeches and news releases are only a small part of the vast amount of educational tools available. One of the best tools that we can use, which is very inexpensive, and which many times is not fully used, is the well-informed progressive conservation officer and the aggressive member of the local Izaak Walton League Chapter or other civic and business groups. These individuals are especially convincing in telling the conservation story when the story they tell to the other person recognizes the benefit he will receive from conservation. It is the educational responsibility of the administrator to understand and interpret his program in the light of the benefits for those he wants on his team. If he wants business men to support his program, what are their benefits? If he wants the farmer to support his program, what are his benefits?

After the administrator has determined the answers, he must see to it that his department's employees know that story, that his conservation officers can tell that story, and that the aggressive wildlife conservation worker also knows it. Where an administrator fails to do this, we have well-meaning individuals telling a story of wildlife conservation based on their individual interest or on a single benefit phase. The listener, in such a case, evaluates the worthiness of the complete program on what he has heard. If the story is weak you've lost a customer. Such individuals are quickly cataloged as fanatics and they lose more sales than they make. It is the administrator's responsibility to see that these well-meaning individuals are helped so they can and do tell a wildlife conservation story of real interest to the person with whom they are talking.

Another opportunity that exists for putting across the wildlife conservation story, and that is a part of education, is through close program cooperation with agricultural conservation interests. You have accomplished a lot through such cooperation already with such groups as the Land Grant Colleges, Extension Services, and Soil Conservation Districts. But even with this excellent beginning, there still remain vast benefits through even closer cooperation.

The conservation work of farmers and ranchers of our country offers a great potential for wildlife conservation benefits. Yet, many times it is difficult to sell a farmer on wildlife conservation—not that he's against it, but because he feels he should concentrate on activities that bear more directly on producing a better income on his farm. After all, the farmer *is* a business man, and if he doesn't concentrate on operating a profitable business, he will soon go out of business.

Here is the advantage of a tie-in sale. When farmers apply a good program of soil and water conservation on their farms, this program not only benefits them in an economic way, but there are also many benefits for wildlife interests. When trees are planted, when multiflora rose is planted, when firebreaks are plowed to reduce the spread of destructive fire, when an agricultural conservation practice is applied —there are wildlife benefits. Eeven the food that wildlife eats when grown on conservation farms helps to bring about better wildlife development. Research in Missouri has shown that rabbits and other animals, both domestic and wild, do not develop strong bodies if they live upon food grown on poor, fertility-depleted soils. In fact, I am told, that research workers have found that rabbits become sterile when certain elements are lacking in their food, elements which, in many cases, are missing when crops are grown on highly eroded land.

In view of this, those who are now on your team should learn of this tie-in advantage. No doubt most of them know of it. But are they doing anything about it? Is the average wildlife conservation supporter in a position to sell farmers, when he comes in contact with them, on the benefits they reap when they practice a good program of soil and water conservation? Yes, this type of educational approach is also the responsibility of the administrator.

When we look at and study the question of the administrator's responsibility in conservation education, the area of possible activity seems to extend far beyond the horizon. I am reminded, too, of the third question Mr. Olds stated: "On limited budgets, what type of approach to a conservation education program will give the greatest returns?"

As I have mentioned, conservation education *is* or *should be* the base of your whole program. But as a government agency, there is also a basic responsibility to operate a program—but a good program —on as small a budget as possible. One observation that administrators should look at is this: "Although the administrator is responsible for the success of his wildlife conservation program, he is not solely responsible for wildlife conservation." The businessman, the professional man, John Doe—all have a certain amount of responsibility. The amazing thing is that when given an opportunity, many people will do something about responsibility of this nature. They will work as volunteers and do an excellent job if they are properly guided. About all this ready source of help demands is (1) That they be sold on the importance of the job to be done; and (2) That they be given an opportunity to do something about it.

There are always young business executives who need an opportunity to get before the public—and who would welcome a chance to work on a constructive wildlife conservation program in their state. These people could carry the conservation story to other business people. Publishers of newspapers and magazines are always willing to devote either their own energy or that of aspiring reporters and editorial assistants for public programs. The same is true in regard to radio station personnel. Public programs should make greater use of such people by providing them opportunity to join the team as volunteer committee workers.

Why not also make use of older men who have retired from active business but who with many capabilities still want to contribute to the welfare of our society? I know of such people and they would be willing to help if they are asked. You know of them too.

Yes, we've discussed conservation education as a responsibility. But in reality it is an opportunity—an opportunity to prove that the American democratic way is the right way, the only way to get a job done.

DISCUSSION

DR. R. W. ESCHMEYER (Executive Vice President, Sport Fishing Institute, Washington, D. C.): One point bothered me quite a bit in regard to conservation education, and I believe I can give it best by citing an extreme example, an example of a state where sportsmen's organizations—the national ones—are well represented, where we have excellent campuses, and where one school has, for years, been doing a big job in conservation education; yet the conservation department, which should be most vitally interested in that state, does not get out as much as a press release or anything else.

I want to give the schools credit without identifying the state, and it isn't easy to do. I was thinking of Purdue; we won't mention the state. (Laughter)

We can go farther east, for you easterners. I know of a big school that has been in conservation for years, and yet its state doesn't as much as get out a press release from its game and fish department. That school is Yale; I don't identify the state.

We could cite more examples of that sort. It makes me wonder how much of our time we are spending on basic fundamentals. What is it you want to sell in conservation education? How do you sell it effectively? And how can we measure whether we are selling it or not, even though we are trying to?

One other question has bothered me a little. When I came to Washington a few years ago, a fellow tried to educate me in conservation. He was an optimist, admittedly, and he was also trying to be reasonable. He said, finally, that he could condone the killing of a fly or mosquito, but killing a fish—that he could never condone, in his mind. That was conservation education.

Seems to me that he forgot one critter altogether, and a pretty important one, one that I have kind of taken a liking to—our fellow human beings.

I believe conservation is aimed at making our lives—your lives and mine—more worth while.

In research, which is my field, we fellows used to say in the thirties, "If we just had the money, if we just had the opportunity, we'd go to town." The money has come, the opportunity has come. I haven't quite figured out yet where we are.

Now, in conservation education, the opportunity is there. The folks are hungry for it. The old adage that opportunity knocks just once is wrong. It's knocking every day, and I'm afraid at times—in my more pessimistic moments—that we are still figuring how to get that door open.

Those are the points I would like to bring up. First of all, we should stick to fundamentals. Secondly, conservation is for us. Third, the opportunity is there. If we aren't getting things done, we professional conservationists are to blame, and not the public.

We have had two very excellent papers, and they represent two important habitats, the campus and the off-campus. They are different. It's a little easier to sell in the first. There the student buys temporarily, or he flunks. In the off-campus habitat you don't have that advantage, as some of us have learned.

We'll get to the off-campus idea. We'll get recommendations for printed material. There are also personal contacts. You con't flunk them if you will listen to them. Will you evaluate this for us in your minds? I'd like to see you do it.

MR. HUDDLESTON: You mentioned that you can't flunk them. The business man can flunk if he doesn't use some of the public relations opportunities that exist at the local level in working with people. There is one thing that comes to my mind. The farm equipment industry, as I mentioned, printed a vast amount of material, and I'm sure all of us received some of it. With all the material put out today, we can't begin to read half of it.

When I was working with Bert Robinson in the Soil Conservation Service, we helped the industry prepare a booklet, "The Farm Equipment Dealer and his Soil Conservation Difficulties," which outlined what a dealer or business man gets out of conservation. How does his business improve when he works with the farmer and helps him and encourages him to put conservation practices into effect on his land? Well, I'm sure a great many of these booklets hit the "round file," just like everything else does these days.

This thing didn't begin to succeed until a simple one-sheet questionnaire was prepared. Thousands of these were printed. They were given to the branch managers and other men of the farm equipment companies, and these men actually went out with dealers on it. They gave 10 of these questionnaires to each dealer. The questionnaires asked the dealer to go out and call on a farmer and ask him such questions as "How much more income have you made since you have applied a certain practice? How has it changed the situation on your farm, equipment-wise?"

Well, actually, dealers did not begin to appreciate the opportunities in working with farmers on conservation until they actually made these calls.

In encouraging dealers to call on farmers and to get them to fill out questionnaires, our sales objective was not in the picture at that time, yet it so happened that when one dealer actually called on 10 farmers and filled out these questionnaires, he did sell three tractors, which shows the benefit of an individual contact. I'm sure that dealer has taken a decided interest in conservation.

But it is the end product of an individual contact. Many of us have come to look on printed material and other things as merely tools to gettting the job done, and in most cases it does take an individual contact somewhere along the line.

I don't know whether this answers your question.

I'd like to see how many of these state department heads actually use advisory committees from industry in any way whatsoever.

DR. ESCHMEYER: I believe that is an embarrassing question, but we'll ask it. What about Minnesota?

MR. CHESTER WILSON (Commissioner of Conservation, State of Minnesota, St. Paul, Minn.): Our advisory committee has been appointed by our Governor. It has been very helpful in educating the public and also in educating the legislature. We are thoroughly sold on the idea, and we have special advisory committees on different subjects.

DR. ESCHMEYER: What about the other states?

I believe your question is answered—one state, sir.

A FACTUAL PRESS RESULTS IN A CONSERVATION-MINDED PUBLIC

LYTTON TAYLOR[1]

The St. Paul Dispatch *and* Pioneer Press, *St. Paul, Minn.*

The accumulated procedings on these North American Wildlife Conferences are building up into the greatest storehouse of knowledge the world has ever known. But the 1,400 or so delegates here are well aware that all of the things that are known probably are insignificant by comparison with what is yet to be learned.

In this age of specialists it is not surprising that one all-important phase is being neglected, or that there should be a "let George do it" attitude concerning things relating to *all* the phases of wildlife and natural resource management.

One of the important things that there is an inclination to assume some one else is taking care of, is the passing along to the public of the things that are being learned and accomplished from day to day.

For example, there is a widespread but completely erronerous assumption that the information that is being exchanged here today somehow becomes known and understood by the masses of tomorrow. There also is a feeling in some scientific circles that progress reports to the public are not of great importance. I even have heard wildlife bureau heads declare that "what we are doing is none of the public's business."

It is not surprising to me, then, that this "tell them nothing" attitude is followed by complaints by administrators that they are hampered and embarrassed by lack of public support, understanding and cooperation.

If it is true that "the biggest problem in managing wildlife is managing people," it seems equally obvious that the people are balky because they have not been informed, that they are skeptical of modern practices that go contrary to tradition because they do not understand.

As an illustration of this balky public attitude, I have just heard of a Chciago business group that conducts a monthly slogan contest. The winner becomes president of the club for a month. The motto submitted by this month's winner was: "If you don't understand it—oppose it."

The remedy for this situation is conservation education. This is still a comparatively new field, and from what I have seen of it, it consists of too many "beautiful generalities" and too little lean, red meat.

There are absorbing and exciting wonders of nature unfolding now,

[1]In the absence of Mr. Taylor, this paper was read by Mr. Robert Stever.

that administrators could channel through the press, and to teachers of conservation education. But I wonder how many teachers of today are able to find the material, and so impress it on young minds that it will remain vividly with them through their adult lives.

There are several reasons why I was reluctant to appear before this conference. First, I have had only a couple of weeks to prepare this paper, and so I appealed to the Outdoors Writers Association of America for a fill-in on the national status of information services.

This brought a reply from Executive Secretary J. Hammond Brown, in Baltimore, advising me *not to attempt it* because, he said, "to do a worthwhile paper on this important subject would require a minimum of several months work," and that I "had been put on a spot."

We in Minnesota hunt game only a few weeks of the year, but we have no closed season on wildlife administrators.

Information services in Minnesota range from non-existent to shockingly deficient, but I do not wish to appear to be gunning for any administrators. They may be doing all that can be done with what they have to work with, and I value their friendships highly.

But even with these misgivings, I believe I can shed some light on my subject. Whether the obstacles I encounter are typical is open to question, because there was no time for studies of all the 48 states and Canada and Mexico. I *do* know that some states have highly commendable services, and it is Mr. Brown's observation that "some federal departments send out information on a fairly workable basis, but the *best* of them leave something to be desired."

In our state fully half the population is authorized to hunt or fish, and these are all potential readers of outdoors columns. To borrow one of Dr. Eschmeyer's expressions, all of these people want to know why the time between fish bites is so long, and how it can be shortened, and why game is harder to find and bag limits and seasons grow shorter and shorter.

I have often heard outdoors writers in general criticized for talking too much about bag limits and too little about basic resources. But if these critics could work in newspaper offices for a while most of them would be converted.

No one has time to read everything that is in thick newspapers, and if you will stop to think, all of you in this room will realize that you select and read only the articles that interest you.

The fisherman who is all hot and bothered because fish won't bite when he wants them to bite also is a highly selective reader who must be led into reading what a writer wants to tell him.

I think the outdoors writer who fails to point out that fundamentals are being neglected in nearly every case, where game or fish productivity is being impaired or lost, is missing the opportunity to be of great service to his community.

But a little sugar coating about shortening the time between bites is the best bait I know when I am fishing for fishermen!

I know from experience that when they are shown their fishing is going to pot because the fields and hillsides are being washed down and deposited on the bottoms of the lakes, fishermen become real crusaders to save the water by nailing down the land.

But a writer must lean on the professional wildlife workers in the field for his day-to-day supplies of information, and even the most awe-inspiring warnings fall flat and lose their reader appeal, unless they are constantly given new "twists" to show the connection between destructive soil and water practices and the lack or abundance of wildlife, whether land or water types.

The Region 3 headquarters of the U. S. Fish and Wildlife Service is located in Minneapolis and serves Minnesota, Wisconsin, North and Sonuth Dakota, Ohio, Michigan, Indiana, Illinois, Missouri, Iowa and Nebraska. The state offices are in St. Paul.

Both the Minnesota commissioner, Chester S. Wilson, and the federal regional director, Dan Janzen, freely admit that their agencies receive steady flows of newsworthy wildlife and nature items. These items are particularly abundant in field reports to headquarters, but they are, to a tragic extent, promptly filed and forgotten. Wilson contributed the following toward preparation of this paper: "Money spent on conservation education is the spearhead of all our progress toward conservation of our natural resources. Every dollar so spent gets more results than any other spending we do."

Janzen said: "I think that if we had authority to use some money to provide information through the press that would help toward conservation education, that the results might be of greater benefit to the public than any other use we could make of the money."

The state conservation agency has an income of more than $4,500,000 a year, largely from licenses, and the federal resources are still greater. It would seem logical then, that if conservation education gets more and better results than any other activity, as Wilson and Janzen agree, that a substantial part of the income should be spent for this purpose, say a minimum of 10 per cent, or at least $500,000 a year.

But if such a proposal seems reasonable, hold your hats!

The 11-state federal agency is not spending a single cent for conservation education, or any other kind of publicity, and never has, to the best of my knowledge. The state has $39,000 a year for salaries of 11 persons in its "bureau of information," but its top "information specialists" are limited by civil service to $302 to $344 a month. By contrast, the minimum wage for experienced newspaper reporters in St. Paul is $485 a month, and half of all these reporters receive $500 and up.

The inevitable result is that skilled reporters, with the best "noses for news," either do not enter, or do not long remain in public service.

The Minnesota state service has had some of the most brilliant young men in America, in their fields, in the last ten years, including the chairman of the technical sessions of this conference. It also had one information writer who, for a while, demonstrated that everyday affairs of a wildlife agency can make fascinating reading for the public. But he, too, long since found richer hunting grounds.

Meanwhile, outdoors writers, in Minnesota at least, are running into almost complete roadblocks. A few in St. Paul and Minnesota manage to dig out some items by questioning state and federal employes.

But Minnesota alone has 431 newspapers, of which 364 are weeklies, and those outside St. Paul and Minneapolis are effectively barred by distance from access to wildlife news. It is equally impractical for outdoors editors in the ten other states to travel to the federal headquarters in Minneapolis to dig out their own news.

This brought comment last week from Ralph Keller, manager of the Minnesota Editorial Association, that "unless the administrators do start informing the public, through the press, of some of the worthwhile things that public agencies are doing, the tax support for them is going to bog down, for sure."

The administrators have plausible explanations. Wilson declares that his bureau of information has "the best people that I can get—for the money." The Fish and Wildlife Service blames Congress.

I am told that in 1951 Congress forced a 25 per cent reduction in information specialists on top of a general 10 per cent cut, and followed with further 10 per cent reductions in 1952 and 1953. How all these percentages can be subtracted from almost nothing to start with, is a mystery to me!

It is of vital interest to the agencies themselves that they let the people in every corner of every country know what they are doing. The best way to do this is the big question.

The matter is not so simple that a clerk can be instructed by a supervisor who has had no newspaper experience himself, and thus become an "information specialist" overnight.

I think the first qualification is a natural aptitude, and this must be fortified by long training and experience. Such a person carries a lot of responsibility, and earns and should receive compensation sufficient to curb the temptation to wander.

It may seem a contradiction, but I am not entirely lacking in sympathy for the traditional viewpoint of state legislatures and Congress that public information services should be kept on starvation budgets, lest they be used by the administrators to propagandize their own works.

I have seen that happen to some extent, and I do not know of any assurance that more of it would not be done if they simply were given more money.

Some consideration has been given by the Minnesota legislature to the setting up of an independent information service, answerable only to the legislature. A reasonable appropriation would get a competent staff, and this would bring joy to outdoors writers. but whether such an agency would be less subject to pressures and influences I do not know.

There is another apparent glaring inconsistency here that will be spotted chiefly by other newspaper men. It is the fact that in pleading for more and better state and federal information services, I may appear to be championing "handouts," meaning things that purport to be ready-written news articles that are handed to newspapers by the bushels every day.

Actually, handouts are held in the lowest esteem by most newspapers, and especially handouts distributed by public agencies. I personally can't recall when I have received a handout, usually called a "news release," that I could pass along for publication without a thorough investigation, revision and usually amplification, including an explanation of the other side, if it happens to be a controversial matter.

But handouts do furnish invaluable leads and tipoffs that the outdoors writer can investigate, verify and develop.

To summarize: I think that information services are the most neglected, yet potentially one of the most important phases of wildlife management.

I think that where there is no information service, such as at the federal regional offices, funds should be juggled so as to permit creation of such service.

I think that press-type cameras capable of taking quality photographs should be standard equipment of all game and fish research teams;

And that information specialists should be paid salaries equal to those paid for comparable work elsewhere.

DISCUSSION

MR. ROBERT CAREY (Joliet [Ill.] News): I would like to say that there is no end of good stories and good information connected with our state conservation department and our research group in the Natural History Survey. I spend as much time as I can in running down stories for these groups. I talk to these men rather than wait for releases, because I find I get much better stories. I found something else in reporting the stories. The term, "conservation," in my estimation, is absolutely worthless in the press. It means too many things to too many people. I jotted down a few things here that I thought might be appropriate.

If we are discussing game management, we use that term, not "conservation." The same with fish management, or forestry, or land use in an agricultural sense. It is only when we use those terms that the people understand what we are talking about.

The people I try to get to are not only the sportsmen. I try to get to the general public as well. Most of the sportsmen realize the situation, because it pinches on them. They know we don't have sufficient game, particularly, but to try to work through them entirely would not do; you would wind up more or less like a mutual admiration association. We are trying to reach the biggest share of our readers who are not sportsmen. It's a little hard to do.

I have found that the best information I have been able to obtain has come through the University of Illinois. I think we get material on a much higher level through our educators.

MR. LYNN CALLAWAY (Department of Conservation, State of Illinois, Springfield,, Ill.): I'll have to thank Bob Carey for saying he can get better news releases by going out and getting them himself than he can from our department. That is exactly right. I had the same experience when I was a newspaper man and an outdoor writer, because we are limited by a bit of red tape in releasing our news stories from the Department of Conservation.

I have been very interested in this discussion here this morning, because I head the Division of Education in the Department at Illinois, and we are trying to do a complete turnover in our educational program, and we are getting a lot of good tips here from you people, and from the discussion so far, I think we seem to be heading in the right way.

I am very proud of the way the outdoor writers of Illinois, in particular, and the whole organization—the Outdoor Writers of America—cooperated with the Department of Conservation here, and with all the other states. I think the outdoor writers have the greatest opportunity in our country to help us in the conservation movement. I have been very happy to work with them as a member of both organizations. I hope to keep on working with the outdoor writers as long as I can stay in conservation work.

MR. JACK VAN COEVERING (Detroit Free Press, Mich.): You know the old saw about "If you're going to train a dog, you have to know more than the dog." I'm not going to say who the dog is in this situation, whether it is the outdoor writer or the administrative agency. You can figure that out for yourselves. Sometimes, I suppose, the one trains the other.

Let me only say this, that a newspaperman's first responsibility is to his newspaper, which means to his readers. Consequently, he is not primarily an educator. He is a dispenser of news, which must be interesting and worth reading. If it isn't interesting and worth reading, we newspaper men will soon be out of a job, and that doesn't just apply to outdoor writers, but it applies to any sort of a newspaperman, because if people don't like the newspaper, they're going to quit buying and reading it.

We who are outdoor writers are a queer combination of things. We are newspaper men, primarily, but all the fellows I know in the business—I would say 80 per cent of them—have some kind of a crusading spirit in them. They are outdoor folks, hunters and fishermen. They want to preserve this thing which they are passing on to other people, and so we are a queer type of newspaperman. We are dispensers of news. We try to make it interesting and at the same time we have this crusading spirit that wants to save natural resources, particularly in terms of hunting and fishing.

So there you have it, and if we can keep that combination in proper balance, I think we can keep on doing a job.

MR. HOWARD SHELLEY (Oakland County Sportsmen's Club, Pontiac, Michigan): Perhaps I am one of the few representatives here not working with the daily press. I am a representative of the Oakland County Sportsmen's Club, of Pontiac, Michigan, and it is my job to disseminate news, both conservation-wise and hunting- and fishing-wise to our 3,500 members, so possibly we look at the coverage of news and conservation, again, a bit differently from some of the others.

Touching on the thing that my good friend, Jack Van Coevering just mentioned, I honestly and sincerely believe that 80 or 90 per cent of outdoor writers have conservation back in their minds. Agreeing that most of them have to dispense the news first, I believe that the outdoor writers in Michigan are doing a splendid job of teaching conservation education.

I think that practically all of the outdoor writers are likewise affiliated with the Outdoor Writers of America, and I think that group as a whole, more than any other group of writers, is doing a whale of a job in teaching conservation education.

Touching specifically on my own area, it is a countrywide organization. However, we touch upon Detroit, and consequently we have many members there. They are interested not only in just what is going on in our own county; they are deeply interested, by the same token, in state and national news, so in my own publication we have the three elements that we touch upon. We try to touch upon the pollution problem in our own back yard, and by the same token, we are deeply interested in our own Great Lakes fishing license, for instance, that we are all hoping to get through. By the same token, we are deeply interested in Dinosaur National Park. So we have several things that we are trying to do, and again, I think the outdoor writers are doing quite a good job. We are trying, at least, to touch upon conservation.

MR. STEVER: Those are the names I was given to call on. If there is anyone else who would like to say anything at this time, we are running a little short, but if anyone wants to say anything, I'd like to hear from them.

MR. DOUGLAS WADE (South Carolina Wild Life Resources Department, Columbia, S. C.): In this technique just used, I watched the reaction of the audience, and it picked up considerably. I would suggest to the folks running the conferences that they study very critically the methods of getting across the various messages. My own interest picked up immediately when you took on the job of calling on these volunteers for extemporaneous talks.

MR. STEVER: Thank you, sir. [Applause]

MR. VAN COEVERING: Mr. Chairman, I was sitting back there and talking with some of my fellow writers, and I mentioned this to one of them and he said, "Why don't you tell the rest of the group?"

About twenty-plus years ago, when I first began doing the outdoor page in the Free Press in Detroit, we had one hunting and fishing club in that area in Detroit. I just wanted to say this, that the outdoor writer can't do it alone. Since that time we not only have the Izaak Walton League (which we had at that time) but as many as 30 or 40 various types of other groups. We have an Audubon Society which is problably one of the strongest in the state. We have natural resources groups. All of these other groups have become interested.

All these groups that are beginning to pitch in to help this whole conservation picture, but I do feel that perhaps all of this stuff in the newspapers had something to do with the creation of these other groups.

MR. STEVER: Jack, I'd like to ask just one question if you, please. I am acquainted with the very fine work that your Michigan metropolitan dailies do. I would like to know how many of the smaller weekly papers in Michigan have outdoor columns.

MR. VAN COEVERING: Most of the dailies carry the "handouts," as we call them (and that isn't quite the right word) of the Conservation Department. Many of our weeklies have editors who are members of our Michigan Outdoor Writers Association and who are vitally interested in the outdoors. A number of them carry columns by the editor himself with some kind of outdoor title.

MR. W. L. APPLE (Arkansas National Wildlife Federation, Little Rock, Arkansas): To my mind, the outdoor writers are the most potent force that we have in the United States today for putting over the message of conservation.

You may be under the impression that only people who hunt and fish read the column, but that's not true. From my own experience in writing columns for the Arkansas Democrat, in Little Rock, I have found that the larger part of my correspondence came from people who are interested in conservation but who did not actually hunt and fish.

I think the outdoor writers are putting over a message to everyone, although they may think they are directing it only to those who hunt and fish. My hat is off to the fellows in the outdoor field who are putting over such a grand job.

CONSERVATION FACTS NEEDED BY WOMEN

GRACE O. BEACH

Izaak Walton League of America, Chicago, Illinois

I deeply appreciate the opportunity to discuss with you the administrator's responsibility for conservation from a woman's point of view and "The Facts Needed by Women's Clubs." The members of the program committee are to be congratulated on their choice of the theme, and the subjects for discussion on this panel.

I'd like also to commend and personally thank them for so boldly using the word "conservation." I notice it appears six times on the page of the program given to this particular session, three times by itself, and three times linked with equally important words—conservation-information, conservation-minded, and conservation-efforts.

I have litle patience with those who pussyfoot around, spending valuable time scanning the dictionary for other words to use in its stead, or coining a word to replace it, when they should be at work putting proper emphasis and meaning to this perfectly good word, pregnant with meaning. Oh yes, I get a kick out of flicking a fly out into a mountain stream and having a trout rise to the bait, and that unexplanable something that happens when you battle an Atlantic salmon on a light flyrod and watch him make his leaps in a try for freedom—the joy of sleeping on a balsam bed in the Canadian woods. Just as much as any of you here, I love the bark of dogs and the crack of the gun on the frosty air, the thump of your heart when a grouse explodes at your feet—you drop a pheasant. I know, I've done them all. There is plenty of excitement, romance and glamor in the sport and the outdoor recreation. But conservation is conservation, and don't tell me there is any glamor in conservation.

There is no glamor in a can of beans, but Heinz dressed it up to the point where people all over America unfailingly picked those attractive red-labeled cans from the grocer's shelf. They did it through education.

Did you ever stop to think how quickly our American housewife was taught how fascinating life can be with a can opener in her hand?

There is just as much glamor in conservation, if you put it there. Glamor is applied, but it takes effort and technique. Natural resources can be just as glamorous as your efforts and techniques make them. Look what Rachel Carson did in her best-seller, *The Sea Around Us,* or how the State of Pennsylvania glamorized her doe deer.

Women can be taught the fascination and benefits to be derived from good conservation practices just as easily as they were taught how to use a can opener. That's where administrators and resource professionals are falling down on the job.

Through my association with the Pennsylvania Game Commission, I realize only too well there is no profession in the world that has as many armchair generals and barbershop biologists, giving advice and direction, as do the resource professionals. Every hunter and fisherman in the field and every other person interested in the outdoors, millions of people, are busy as beavers on the job. You technicians are not going to like this, but much of the fault lies at your own doorstep. You let them take on the education job. They are educating you, instead of the other way 'round.

Practically all the education work done in the field has had most of its guidance from the army in the field. You have been conspicuous by your absence. The people in America have been begging to have conservation education under proper guidance added to the other subjects until it has reached the proportions of a demand. Yet, with some few exceptions, you continue to be die-hards, wearing blinders, plodding along in the old rut. The very fact that, today, we are here discussing "The Administrator's Responsibilities in Conservation Education" proves the point that you have been deaf to the growing demands and must still be sold a bill of goods. I've noticed, too, that when you have to cut costs, the first things to feel the axe are generally your best vehicles for education and public relations, your bulletins and magazines. This points up your weak spot very graphically.

Through the years, however, guided or misguided conservation education efforts have developed new attitudes among our people as they began to see in natural resources the economic factors they never saw before. It has even reached the press and the industrial field and they, too, are taking a hand. Yet fish and wildlife people lag far behind. This is due, in the main, to the fact that you are not properly evaluating the subject. You can measure license fees in dollars and cents, but you cannot see the dollars and cents value in education. Some of your early ventures in the educational field have back-fired because you used it entirely for propaganda purposes, and to your great consternation you were highly criticized by the very people you aimed it toward. You made the mistake of tacking the emphasis on putting fish and wildlife into stream and field instead of showing where it rightfully comes in—as a natural product of good resource management.

A great body of American women has also come to realize that our economic well-being lies in the restoration and conservation of our natural resources. Let me be specific. In the Federated Women's Clubs, the Garden Clubs of America, and the women chapters of the Izaak Walton League of America, all have established departments of conservation and have national, regional, state and local chairmen. Like everyone else coming into this confused field of endeavor, they have had to stumble and grope, feeling their way in the dark.

As Editor of *Outdoor America* and a member of the Izaak Walton League staff, there is a constant flow of requests coming over my desk from women members of the League and other groups asking for assistance and how and where to get guidance, educational material, any sort of help. Some organizations and agencies have given them every cooperation and help available, but all too often the door has been slammed in their faces.

In talking with Florence Byerrum, conservation chairman for the Federation, and some of the women who head up the Federation's wildlife commitees, I was amazed and disturbed to learn that with few exceptions they got little, if any, help from their State Fish and Wildlife departments. You had no material, no program, no plan to offer.

You're misisng a good bet. In the Federated Women's Clubs of America and the associated groups are over five million women. Your state has its fair share of these organized women, interested and wanting to learn. And their ranks are steadily growing. What a present and future potential! Think of the value and benefits that could accrue and the impact on public opinion if this great body of women were properly informed and understood the problems.

Don't forget, there are a lot of young women already at work in the resource department field in 4-H Clubs, Girl Scouts and Campfire Girls. Some of them have been chosen as delegates from their states to the first annual national Young Outdoor Americans' conservation planning conference, a new program sponsored by the League. They are arriving in Chicago today and along with the young men delegates from major youth groups will spend the next few days discussing and making some recommendations on some very deep and vital natural resource subjects. Some of you sat in on the Governors' Committee meetings and you already know of their outstanding contributions and that these young women and men are out in front. These organized young women add to the potential.

You can be of invaluable assistance in giving proper guidance to these conservation and wildlife programs being carried on by women's clubs and other organizations.

Some of the specific things you can make available to your state and local groups that are so badly needed are:

1. Kit program material. Much of this they have had to make up themselves.
2. Help them in the selection of subjects for discussion and supply the facts pertinent to the subject for proper guidance.
3. Suggest and supply speakers who will give them factually correct information and assist in guiding them into proper channels of thought.
4. Supply and suggest films that are pointed to the proper educational values, rather than entertainment values. Remember this, if these women were only interested in entertainment, they wouldn't be there.
5. Supply material and suggested material that may be distributed among the clubs and club members.
6. Assist the chairman by suggesting and helping to plan programs and projects they can undertake.
7. You can also conduct a school for club women. This has been done by the Illinois Conservation Department. It's a 3-day annual affair, and the ladies pay $3.00 a day to attend. Wisconsin and Michigan also hold such schools.

The ladies are willing and want to learn. They get a great deal out of these schools, and if they understand the problems they can do a better job of helping. As one woman put it, "I no longer see as predominant the limpid beauty in a deer's eyes; I understand more fully the problems connected with deer management." If we had all learned that story sooner, there would have been far less difficulty in the deer story.

Women need the facts. All the facts.

They will carry on the program in the future as they have in the past, with or without your help, of that you can be sure. But they can be working for you. Your department and the whole conservation program will be benefited greatly by their help. They can do a quicker, more efficient job if you give them the facts and a job to do.

You have the background, the education and know-how, if you just go back home and put them to work. Take your rightful place as leaders in conservation.

BETTER GUIDES FOR CONSERVATION EFFORTS OF SPORTSMEN

MALCOLM M. HARGRAVES,* M.D.
Mayo Clinic, Rochester, Minnesota

The American sportsman, individually and collectively, has been and will continue to be a dominant force in the conservation movement. The other great force is the farmer and his social-business organizations. Unhappily these two powerful working forces are often at loggerheads, generating much frictional heat and making little conservation progress. Fortunately, however, there have always been enough sportsman-farmers in each group, equipped with leadership and common understanding, to smooth out the immediate difficulties and permit the resumption of movement. You will note that I have used the phrase "permit the resumption of movement" rather than "permit the resumption of progress." This is a calculated statement. My dictionary defines progress as "proceeding to a further or higher stage" or "advancement in general" or "continuous improvement." There is no one in this audience so naive as not to appreciate that the "Conservation Movement" has been anything but smooth and brilliant progress; it has been a succession of painful forward and backward steps over the years. On the surface, we would have seemed to have made some progress, but history will record our accomplishments, as it has those of peoples before us. If it is not progress, history will record the story of another lost people.

So let's face up to the facts and admit that "our handling and our harvesting," our "wise and judicious use" of our natural resources, has been a most unhappy story. And let's further face up to the fact that progress, rather than aimless and often disastrous movement, might have been ours had we possessed two things: first, an adequate conservation education, and second, an ecological conscience. That we have had little conservation education and less ecological conscience is a truism. That we are one of the dominant world powers of today is a tribute to our energy and inventiveness rather than our vision, for we have lived, worked, and played in a country vast in expanse and rich in natural resources. Under such circumstances it is not strange that our national ecological conscience has seldom stirred from its slumber nor that we have seldom gotten conservation education beyond the parlor and hot-stove league stage.

There are, of course, exonerating circumstances:

First—our very industrious pursuit of more material prosperity in an already prosperous country has given us little time to contemplate history.

Second—people have a way of having to make their own history and are seldom influenced by the mistakes of other civilizations. We have followed the usual pattern. In fact, it would seem that making one's own history is an inescapable consequence of living on a particular watershed. Consequently, only broad conservation principles are applicable to the whole, while specific, local problems have required individual solutions.

Third—because there have been so many specific local problems lacking solution, such broad principles of conservation as we knew, have seemed inadequate to the involved people and they have brushed them aside for hasty, independent, and often unwise action.

Fourth—since conservation education of necessity deals in history and broad principles primarily, and gets to specific problem solutions secondarily, it has usually been defeated in its efforts before it got well started, *i.e.*, conservation education should have preceded the state of emergency.

Fifth—the solution to specific local problems usually requires the experimental approach, involving broad biological principles applied with plenty of horse sense and sensitive understanding. It is a rare occasion when all of these ingredients get together!

Sixth—since most of us are of necessity provincial in our viewpoint, surrounded by unsolved local resource problems, it is little wonder that we lack an ecological conscience to tell right from wrong in our daily relations with a world that hasn't yet revealed many of the rights from the wrongs.

And lastly, just in case I have eased too many consciences by this array of rationalization, let me add that we have been too stupidly selfish to much care what the future held so long as we got ours while the getting was good. Now that the getting is no longer so good, "the wailing and anguish toucheth even the hardened of heart."

But to return to my opening statement about the American sportsman being a dominant force in the conservation movement—that is not an accidental happenstance! In fact, I venture to say that our conservation accomplishments, assuming repetition of past mistakes, would be twenty years behind today's mark if it had not been for the sportsman and his vociferous efforts. As one looks at recent history, a series of circumstances would seem to substantiate this statement.

First—fish and game are now recognized to be a product of the land, differing only in degree from the fixed, harvestable crops of the farm and forest.

Second—such wildlife is highly sensitive to environmental change and with a rapidly expanding population, an equally rapid and often reckless expansion of agriculture, timber cutting, and industrialization raised havoc with our fields, forests, and waters. "Proper land use" as a working part of our language was as yet unknown.

As a corollary then, we can say that good hunting and fishing are a by-product of proper land use and we have had all too little of either in the last one-half century.

Third—the sportsman is as sensitive to changes in wildlife numbers as wildlife is sensitive to environmental change.

Fourth—the sportsman, being a vigorous individual and sound of limb and lung responded to this changed environment with hue and cry as well as restless, anxious action; his voice was raised in the town meeting and it rang through the legislative halls; he banded together with his fellow sportsmen and got both concerted action and a bigger voice; he gradually relinquished the quiet pursuit of his sport to vigorously attack the baffling problems of his vanishing wildlife.

Not only was that recent past history, but it is today's action history, and many is the harried administrator sitting in today's audience while feeling the hot breath of this persistent fellow on the back of his neck. Here, then, in the sportsman, we have a great natural resource, the wise use of which could lead to the orderly solution of many solvable resource problems. I say this with feeling and conviction since I, myself, am a farmer-sportsman, as well as a physician, and bear considerable educational and leadership responsibility in this role. In many years of radio broadcasting, banquet addresses, rod and gun club meetings, Izaak Walton Conventions and workshops as well as farm organization meetings of many types, I have found the sportsman and farmer-sportsman eager for knowledge, anxious for action, jealous of his rights but willing to cooperate to gain a worthwhile objective. I speak, of course, of the true sportsman who is willing to work and sacrifice that his sport may live and be renewable for those who follow him. I have little patience and less respect for the selfish pothunter whose only interest is himself, and whose only objective is his own gain.

Our tragic misuse of this great resource is one of the unhappier chapters of our conservation story. Education—conservation education —coupled with action would have saved so much in the critical years! But education comes hard and much that we know now, we might not have known without those years. The greater tragedy, however, is that today we are still doing so much that we should have stopped doing in those past years. Whose fault is it that sportsmen still face problems with firm faith in the old panaceas and cry for greater restrictions of the bag and seasons, more game farms and rearing ponds, more predator control and high bounties, a bigger warden force instead of a bigger research unit, one-buck laws and closed seasons while the forest suffers? Gentlemen, I'm looking at you—willing to accept my share of the responsibility. How about you?

One of the major problems is conservation education which we have muffed consistently is that of unselling the American sportsman on some of his fixed ideas of resource management. The American males' belief in the inviolateness of the home, the dignity of motherhood and the virtues of home cooking *is as nothing* compared to his belief in fish stocking, closed seasons and buck laws. Unhappily, these traditions of the home and field seem to be handed down from father tc son as part of our accepted common knowledge.

Our first great task, then, is that of mass education to free the American mind of its prejudice for limited and often harmful techniques and make it receptive for new ideas and experimental techniques. This will not be easy, but tobacco companies have done it for women smokers, the garment trade for flamboyant men's sport clothes, and the drug companies for laxative radio commercials. I contend none of them are good, but the fact remains that they have done it. In other words—there are successful techniques—let's use them!

Next, the American sportsman must understand that all game management is still largely on a trial-and-error basis and that there are still few fixed rules and only broad principles to guide us. Since all of these principles are bio-ecological, the work should be carried on by scientifically trained men who have a good endowment of hard common sense. Science, like everything else, can get silly and lose all sense of proportion. We have too much at stake to be ridiculous. On the other hand, I have the greatest respect for the sportsman's tolerance for research if he is only kept informed of what's going on and why.

Next our sportsman must understand that our renewable resources are truly renewable. His anxiety over an open season in a year of poor production is often pitiful. Explanations, backed by scientific data, would eventually allay his fears and show him that game production is a year-to-year sustained-yield proposition, other environmental factors being equal.

In the conservation field there is a crying need for interpretation of scientific literature for sportsman consumption. In my own field of clinical hematology I am daily faced with the problem of making explanations to anxious patients and their families; lawyers are faced with the same problem when dealing with their clients; salesmen dealing in machinery, chemicals, or other products must do likewise. It can be done simple and effectively. Research in the natural resource field must be "sold" to the sportsman if it is ever to be effective. We have been timid and non-aggressive in this field. Scientific findings of work carefully and honestly done should be presented to the public in simple, readable fashion and not buried in departmental files nor lost in the pages of technical journals.

And lastly, aggressive and progressive, informed leadership must come from public officials entrusted with natural resource management, and their stand must be backed up by an equally aggressive and progressive, informed group of lay conservation leaders and outdoor writers. The latter is a must since all of us know that the administration can go only as fast as the public will permit. However, I personally do not subscribe to the theory that the sportsman foots the bill with his license fee and so, this being a democracy, his wishes should be law. If we accept the principle that good hunting and fishing are a by-product of good land use, then wildlife becomes only an integral part of our entire land use economy, and that is the life blood of all of us! Thus, the sportsman's license fee becomes a very small drop in a very large bucket, and if he is adequately informed, he will agree and pitch in to work for the big project.

And now a few random thoughts on methods—some I recommend, others are ideas requiring some exploration.

1. Cooperative Interstate (National) Publication. I get, and appreciate, many of the fine journals put out by individual state conservation departments and realize that many are doing a bang-up job where it counts the most, *i.e.* locally. However, in this huge country of mass production and diversified talents could we not have a cooperative interstate publication for wide distribution and dedicated to the conservation education of the public? Many of the less fortunate states could thus have a publication while the more fortunate states could certainly still use it.

2. Let's keep our education program interesting and simple. An educator once stopped me and commended my weekly conservation radio program but gave me a bit of advice which I pass on to you. I was told that when the T.V.A. had gotten all that it could of the local residents signed up to cooperate in the program, a large percentage of the farm families were still reluctant. The program was then explained and "sold" by pamphlet and lecture to the sixth grade school children who took both the ideas and the literature home. Soon a new and large group of cooperators were coming in to sign up! The implication is obvious.

3. As a corollary to the above I would again draw to your attention the tremendous educational possibilities of children's books written by our good discussion leader, Bill Eschmeyer. These, in my opinion, have been magnificently handled by the author and by his publisher. I have tried them out over the air and given them to the children of friends with very gratifying educational results. I am quite sure that many a conservation club would cooperate in placing these and other publications in the rural and city schools.

4. Enlistment of community leaders to back the program. Sociologists long ago determined that one of the most successful means of bettering a community was that of working through its leaders. The Soil Conservation Service carried out a study of this sort in Michigan and then used the results with success. The point is that every community has its natural leaders by dint of intelligence, education, business success, and affiliations. These leaders and their families may be in the background rather than at the front, but their influence usually dictates the success or failure of a community venture. Our job is find them and use them.

5. Conservation Education Workshop and Amateur Game Managers Shortcourse. The average sportsman joins an organization because he has ideas and wants action. Unfortunately he usually lacks the knowledge of fundamental principles to go with his enthusiasm. Each in his own way is an amateur game manager. To reduce the amount of damage he can do and to multiply the potential good he could accomplish workshops and shortcourses are a great boon. The Minnesota Division of the Izaak Walton League has used both vehicles with great success in its membership training work.

6. Interpretation of technical literature for the layman may best be done by a layman with the advice of the trained scientist. It is, of course, a well known fact that people doing the best and most brilliant work in technical fields are often unable to present the results of their own work in simple yet adequate language for general understanding. They need help. Give it to them!

7. Seize every opportunity to work with the educators of our universities and school systems. Every effort put forth to help or to add to the education of a grade school teacher pays big dividends. The worth of this recommendation should be self evident.

8. The outdoor writers exert a tremendous influence on the thinking and education of the sportsman. From a conservation education standpoint these writers present a problem which I will not venture to discuss—rather, I would recommend a little soul searching collectively and individually after pointing out the enormity of their responsibility.

Ladies and Gentlemen, I have taken much of your time and more of mine to present this material. None of it is new but an attempt has been made to bring the sportsman into the conservation picture and to point out his importance, his needs, and his shortcomings. I trust that no one has taken offense and I am sure that none has since I know that you all are sportsmen.

HOW CAN WE LIVE ON AN AMERICAN FARM?

W. HOUSER DAVIDSON

National Association of Soil Conservation Districts, Fort Valley, Georgia

I like the subject your program committee gave me: "How Can We Live on an American Farm?" It's a practical topic, for it asks the question "How?"

I also am pleased that "WE" is emphasized. This word "we" means Houser Davidson, my wife, our son Bill, who is farming with us, and his wife. And it includes our neighbors in the Ocmulgee Soil Conservation District, all the other farm families in Georgia—in fact, the farming and ranching people all over America.

The word "live" means much more to me than "exist" or "subsist," and I'm sure it does to you. To me, it means a way of life—a planned, productive, and profitable but challenging way of life. Thus, it is also a pleasing way.

Today I want to discuss with you some of the challenges which face us in answering the question, "How Can We Live on an American Farm?"

Before I do, however, I want to make three points clear.

The first is that many people who happily speak of farming as a way of life never stop to think why this is true. Well, why is it? My answer is that farming is a way of life because it is—and must be—a *business operation* in the true tradition of American free enterprise. In that same light, then, I think of banking, or medicine, or manufacturing, or merchandising as a way of life.

The second is that good farming begins, but does not end, with conservation. Conservation, development, and improvement of land, water timber, and wildlife are the *foundation* of good farming. On this solid foundation of conservation, you can add good farm management, mechanization, better crop varieties, quality livestock, insect and disease control, credit, and all the other essentials of the farm business. But without the foundation of land wisely used and treated, you or the next man on the farm will go broke, or at best have *farm existence* instead of *farm living*.

The third point is that, in this discussion, I want to emphasize the challenges that face us in putting this foundation of true conservation under the business of farming and thus under what can be, I think, the most pleasant way of life—living on an American farm. My failure to explore such important problems as marketing, prices, mechanization, labor, farm management, credit, and so on does not mean that I or any other farmer can afford to ignore them. All of course have a bearing on how fast or how well we can do planned conservation farming.

What are some the challenges facing us in doing the conservation job all over America?

To me, by far the biggest challenge is that of conserving, improving, and developing our renewable natural resources within the framework of American democracy.

Let me illustrate how I feel about it, and the way I think every other Soil Conservation District supervisor, commissioner, and director feels.

About two years ago a group of Central European exchange students stopped for a look at soil conservation work on our farm. Through their interpreter, I explained that I used conservation methods for two reasons: These methods made money for us, and we also felt it was the right way to farm if you have any regard for your soil. I told them about our yields—100 bushels of oats an acre one year on 190 acres, for example.

While my remarks were being interpreted, one student was sifting that rich red sandy loam through his fingers. Finally he turned to the interpreter and said something very fast in German. Then the interpreter turned to me:

"He wants to know," he said, "why—since your soil conservation work makes your soil so good and gives you such high yields—your country doesn't make all farmers operate as you do."

My answer, and the only answer I know to that question, was this: "Tell that young man in this country we think a lot more of our freedom to farm as we want to than we do of our soil."

Gentlemen, I'll fight and work harder for a voluntary, locally governed program of soil and water conservation than I've ever worked to protect and improve the land, water, timber, and wildlife on our farm.

That's why I am a supervisor of the Ocmulgee Soil Conservation District. It's the reason I accepted responsibilities in our State and National Associations of Soil Conservation Districts when fellow supervisors were kind enough to call on me. It is, in fact, the reason I was delighted to accept your welcome invitation to come to Chicago to talk with you today.

Because I am from the South, you would expect me to believe strongly in State's rights. I do. Yet I have found, in my work with Soil Conservation District leaders all over America, that a strong belief in the rights of self-determination and local self-government is a common denominator of District Supervisors, Directors, and Commissioners everywhere. But we also have an undying belief that: *with rights go responsibilities.*

If we farmers and ranchers demand and receive, as we have through our Soil Conservation Districts, the right to manage our own conservation program, to decide what we want to do, how we want to do it, and whom we want to help us, then—

We must accept responsibilities for local leadership and direction of this work.

I believe that we have accepted these responsibilities. How else can you account for the fact that 13,000 farmers and ranchers are serving as unpaid board members of more than 2,500 soil conservation districts? How else can you account for the organization of these Districts by farmers and ranchers?

When I pick up a handful of that good red soil on our farm, I know that I hold in my hand:

First, my family's living standard today and tomorrow.

Second, the meat and bread on the tables of America today and tomorrow.

Third, a big part of the prosperity of Fort Valley and all of South Georgia.

Fourth, a big part of the recreation and relaxation you and others want in the form of hunting, fishing, boating, and swimming.

Fifth, a part of the schools, Boy and Girl Scouts, other organized youth groups, Women's Clubs, and churches of my community.

And Sixth, an important part of the very foundation of the United States of America!

Those are among the responsibilities of the farmers and ranchers of America.

We have banded ourselves together in 27 Soil Conservation Districts in Georgia to carry out those responsibilities, and at the same time to keep our rights of self-determination and self-government. Districts are political sub-divisions of the State; in all States, districts are actually agencies of the State. We created our districts through the democratic steps of petitions, hearings, and referenda. We developed our own programs and work plans. Ours is a voluntary program; farmers can join us as District cooperators or not, as they like. We persuade, but never coerce.

We aim to keep it that way.

You may be wondering how there could be any challenge to a democratic approach to soil conservation in America.

Let's face the facts. One is the rapid growth of our population. I am told that we have added about six million people since 1950, and that the rate of increase is continuing. But we have added not one acre to our land area, and some of our land is less productive than it was in 1950. To be sure, we have surpluses right now. There can come a time, however, when the upward curve of population and the downward curve of productive land will meet. That's the time I fear.

What will happen if the people in Chicago, Los Angeles, and New York have to miss a meal or have less than they want? They'll want to know why, of course. If they find it's because we farmers and ranchers have wasted productive land, they will want to know why we are not farming the conservation way. Furthermore, they will have the votes to pass whatever laws they think will give them "three squares a day."

So farm democracy rides with the soil conservation district movement. If Districts fail, we will cease to have what we proudly think of now as "an American farm."

Before we pass on from our discussion of "rights and responsibilities," let me add one other thought. The people in our towns and cities have a right to expect a bountiful supply of the products of the lands, waters, and forests of America. To me, that means they also have a responsibility to help protect, develop and improve those resources. They can carry out a part of this responsibility through the public agencies, State and Federal, which help farmers and ranchers solve problems of soil, water, timber, and wildlife conservation. I am thinking of such agencies as the Soil Conservation Service, the Agricultural Conservation Program Service, the state and federal forest services, the state and federal fish and wildlife services, the Extensive Service, the Farmers Home Administration, and others—each with a specific service to perform.

But we soil conservation district supervisors invite—yes, beg—our neighbors in the cities to do more than help support these public agencies with their tax dollars. We want them and their organizations personally on the District team—to work with us on our Program for greater service committees, to help us with the activities of our State and National Associations of Soil Conservation Districts. In fact, we long for the day when every organization will be working as closely with districts and our associations as the wildlife groups are now. And before I move on to the next challenge facing us, I want to express my personal appreciation and that of our associations for the very valuable help being given by the organizations represented here.

The second challenge, I think, is that of *keeping our standards of conservation high.*

We have long known that piece-meal conservation is doomed to failure. Some farmers, to their regret, proved it on their own land. Hugh Bennett also did much to teach us the same lesson—those of us who would listen to him. We now know, through experience and through research, that we must have a complete soil and water conservation program on every farm and ranch. We know that there is a best long-time use for every acre, whether that use is cultivated crops, grasses, trees, or wildlife. We know that we must give each acre the treatment it needs for protection and improvement.

While using the best known methods of conservation, we must always be on the alert for better methods and better soil-conserving plants. We look to research, plus farmer experience, for better techniques. For example, we need to find something that will do for doves, wild ducks, squirrels, deer, turkeys, and rabbits what we have done for fishponds and bobwhites.

The research at Auburn, Alabama, on fish production in farm ponds cannot be valued in dollars and cents. I value the pleasure, the relaxation, afforded by a good fish pond much higher than I do the food produced, as important as that is. There's a spiritual restfulness of the outdoors that we all need in the headlong rush of modern living—a peace that comes with hunting, fishing, boating, or just sitting quietly by a good farm pond.

Well, it was the research on fish ponds at Auburn, plus the carrying of these simple techniques by the Soil Conservation Service to farmers in soil conservation districts, plus the cooperation of the Fish and

Wildlife Service in growing the fingerling bluegill and bass, that is making such relaxation possible on thousands of farms today.

Bicolor lespedeza, which Verne Davison of the Soil Conservation Service did so much to spread in the bobwhite belt, is an example of the type of plant or combination of plants we need for other game. He and landowners learned the best ways to plant and manage bicolor, how to put it in small patches in the open woods and in strips between open land and the woods. These small patches and narrow strips use very little land, but they produce more dependable quail food than many acres in some other farm uses. Once the value of bicolor was proved, our state game departments began producing millions of plants to be used in soil conservation districts.

So I hope that our friends doing wildlife research will concentrate on finding dependable, yet simple, specific, ways of growing more game economically. Although I am a firm believer in planned and organized research, I also believe that research, like gold, is where you find it. By this, I mean that much research work is being done by farmers on their own land. For example, there's a good reason why I don't harvest any more summer legume hay. A few years back, I cut hay from half a field of soybeans where I was going to follow with oats in the fall. When I combined the oats the next June, I made 28 bushels an acre less from the land where I'd taken the hay. I could have bought hay for less than that. To my way of thinking, that was research, and I hope that some farmer by accident or deliberately helps us find better ways of managing land for wildlife.

But research at Auburn, Griffin, Tifton or Athens is without value until it becomes a part of every-day farming operations. Most of us learned long ago that education alone will not get the conservation job done. In making this statement, I am *not* belittling the place of the Extension Services and their county agents, nor the work of the vocational agriculture teachers. I am a graduate of the University of Georgia, a land grant college, and I have served for years as a member of a county agent's advisory committee. I know from personal experience that it takes teamwork by educational and technical service agencies. Thus we District Supervisors have come to recognize that there is no substitute for adequate on-the-ground technical assistance from the Soil Conservation Service, which helps us maintain high standards of conservation. And we look to the Extension Service, the vocational agriculture teachers, and others to help us with the "selling" job.

This reference to "selling" leads naturally into the next challenge facing us—that of *creating a desire on the part of landowners to* *farm the conservation way*. Here I am turning directly to what I consider conservation education.

I think our experience has proved that the average farmer or rancher needs help with conservation, but you *can't give* him a conservation program. You have to sell it to him! You have to create a desire for conservation farming. If you do that, he will "buy" it—buy it with his own labor, use of his equipment, with his dollars, and with his own time and thought. Of course he will need technical help on the jobs he can't do for himself, and he also may need some money—ACP payments, FHA loans, or long-time bank credit.

If we maintain high standards of conservation, as I stressed a moment ago, we will have a quality product to sell—a product that will pay off the farmer in dollars and cents and in personal satisfaction and pleasure that is beyond price. Therein lies the continuing success of our conservation education work.

And important too, we must not forget that all of us have a very important responsibility to see that our youth of today—on the farms and in the cities—have an opportunity to share with us the conservation of our land, water, forests, rangeland, and wildlife resources. Do you know that we have in this country nearly 3,000,000 Boy Scouts—and this is "Boy Scout Good Turn Conservation Year" you know—more than 2,000,000 4-H Club boys and girls; 363,000 Future Farmers of America; 367,000 Future Home Makers—girls in high school—nearly 3,000,000 Girl Scouts; and another younger group, 400,000 Camp Fire Girls.

All of these have pledged themselves to the deed of better future citizenship, and to the conservation of our natural resources. It goes without saying that we have a sincere obligation to these millions of young people. For many years I have given them all the spare time I have had. In later life, they can be a powerful force for conservation if we now enable them to develop the proper understanding and a desire.

I feel that conservation education begins with the school child in the first grade and never ends during his life-time. Attitudes children acquire during their school and Scout days stay with them through life. This phase of conservation education is so important that I want to discuss it more later. I fully recognize that conservation will be better understood and more readily accepted by the farmer who while in the public schools, learned to love our lands, waters, trees, and wildlife. But the fact remains that few of today's landowners had the benefit of this type of early training. It isn't their fault; modern conservation was unknown then. How can we help them change their attitudes toward land use and treatment, toward wildlife? How can we help them change their habits of farming?

Those are questions of great concern to every district supervisor, commissioner, and director in America. As administrators of Districts, we know that those questions must be answered in such a way as to remove obstacles to greater progress of the conservation program.

We need and welcome your help. But before you can give us a great deal of help, we district supervisors must get our own jobs under control. We must accept the leadership given us under our state laws. We must be conservationists in spirit and in deeds, as well as in words. What I am trying to say is that each of us serving on a district governing board must have, or be working as rapidly as possible toward, a complete soil and water conservation program on his own farm or ranch. What influence for conservation can a supervisor be in my section of Georgia who burns his woods or his grain stubble? What influence can he have for complete conservation when he thoughtlessly destroys wildlife habitat?

Thus I believe that the first step in a conservation education program within a Soil Conservation District is taken on the farms of the supervisors themselves.

The second step, I think, is a careful study of the needs for conservation education. Farmers in my section of Georgia have believed in and used terraces for years. Generally they laid off their rows on the contour with the terraces. But too often the terrace water was dumped in roadsides or down the fence row. That meant gullies. We needed education not only on the use of grassed waterways, but also to encourage the completion of grassed waterways *before* terraces were built. Later on, we turned rapidly to mechanized farming. Some men who knew how to plow on the contour with a mule didn't know how to handle a tractor on the crooked rows and point rows. The result: Many farmers just plowed up-and-down hill over their terraces. Then we needed education on the use of tractor equipment on the contour. A part of this job was to "sell" broad-based terraces on which a tractor could be operated more easily.

The third step is for the district board to sit down with agency workers, farmers, businessmen, and others to develop a sound, workable program of conservation education. Making this plan and carrying it out is important enough to challenge the best thinking and efforts of leaders of all agencies and all groups.

You who are interested especially in wildlife conservation and management can be, and are, of great help to us in each of the foregoing activities. You can help us with better wildlife programs on our own farms; can assist us in determining needs, in planning, and in carrying the planned program to the landowners.

But we must do more than work with landowners. We also must *create a favorable climate for conservation farming.* For example, when a cooperator in my district goes to his banker, his doctor, his equipment dealer, or his fertilizer dealer, I want that businessman or professional man to ask about the conservation work the farmer is doing. If the farmer is not a district cooperator, I want the banker to point out the advantages of conservation farming. I want the fertilizer distributor to do the same thing. I want the newspapers and radio stations in my district to tell the conservation story. I want the ministers to stress stewardship of our God-given natural resources. And I want conservation to be taught in the schools all over the state.

As a friend has said, I want that fourth ''R' to be taught in school —Reading, 'Riting, 'Rithmetic, and *'rosion control.* I have little patience with people who talk about saving the soil for future generations, but are doing little or nothing at all to prepare the next generation to do a better conservation job than my generation is doing. I have tried to emphasize the great need for adult conservation education. One reason for the size of this job is the fact that we didn't teach conservation when these farmers and their friends in town were in school. While we're trying to change the effects of that neglect, let's also try to correct one contributing cause.

I am not suggesting here that we can eventually eliminate all need for adult conservation education. We confidently expect many improvements in methods and techniques of conservation—for example things to fill some of the wants I mentioned earlier for doves, squirrels, rabbits, ducks, and other game. We must have a continuing education program to carry this new knowledge to landowners.

It is most gratifying to me and other district supervisors and commissioners to see conservation well-taught in more and more of our schools, and to find it increasingly in the programs of 4-H Clubs, Future Farmers, Boy Scouts, Girl Scouts, and other youth groups.

The final two challenges in building a true conservation foundation under American farming deal directly with wildlife.

One is *getting widespread acceptance by farmers and sportsmen alike of the fact that wildlife is another good crop that can be grown well and more abundantly for harvest.* When we think of game as a farm crop, then we are ready to think in terms of better management, of planned production, of wise harvesting. Until we recognized trees as farm crops, instead of wild things planted and grown by chance, we made little progress in reforestation, fire protection, and selective cutting. I feel it is the same way with wildlife.

Research and the experience of farmers have proved that we can produce larger quantities of bobwhites on odd bits of land by intelligent planning and management than nature alone could feed on much larger areas. The result is a bigger harvest of another farm crop. To some that harvest may be the pleasure of hearing the bobwhite's cheerful whistle. To others, it may be the pleasure of successful hunting with friends.

But the plain truth is: The better the management of lands and waters for wildlife, the better the harvest of the wildlife crop.

We district supervisors look to you to help us get universal acceptance of this fact by farmers and sportsmen.

The other challenge is to *make good wildlife management pay the landowner in dollars and cents, if he wants it.* It takes land and money, work and thought, to protect wildlife habitat on American farms. It takes even more to *improve* and *develop* food and shelter for game, or to build, stock, fertilize, and manage fish ponds.

All this being true, the landowner is entitled to sell his wildlife crop if he wishes.

I know that there is some opposition to this thought. The oppposition seems based on the notion that a squirrel, a rabbit, or a bobwhite belongs to the first person who can draw a bead on it—provided he has a hunting license and does his shooting within legal season.

With more and more people wanting to hunt and fish, and often less to shoot or hook, why not pay the man who has the land and water and is willing to put out the time, money, and thought to grow the crop? Are we afraid of the good old American way of getting production—by paying the man who can do it?

Some farmers will grow more game simply because they love wildlife. Others can manage wildlife land well only if they are able to get a cash return for the use and management of their property. Some may be willing to take land out of other crops—perhaps some of those crops now on the surplus lists—if they know the shooting privileges will bring in cash income.

Here, again, you can make an important contribution to the work of Soil Conservation Districts.

Yes, we can live on an American farm, and live well, if we place under that farm the foundation of sound conservation. On that solid foundation, we then can use management, labor, capital, better crops and livestock, and improved methods effectively and efficiently to create a profitable farm business in the American tradition of free enterprise.

But I am convinced that the greatest challenge facing us is to build that conservation foundation within the framework of American democracy. To me, that means making soil conservation districts work even better than they are today. We supervisors, commissioners and directors who have accepted direct responsibility for District leadership invite—yes, plead—for your continued support and direct help.

DISCUSSION

DR. ESCHMEYER: I think if those of us who have watched conservation moving will admit to ourselves how fast it is moving, we'll get complacent, and not work very hard, so I keep pointing out the very dark side, and yet you can't be pessimistic when you hear these folks talking about fundamentals, no matter where they live or what they do.

I am not worried about conservation, but I will never admit it publicly, or we would all get complacent and smug instead.

We would have another friend if Representative Ben Jensen were here. Knowing his feelings, I know he would talk on fundamentals, too, and like the others, he would certainly stress highly the human factors.

I got a letter from Judge Long in Seattle, a few days ago. I would like to read it, since Representative Jensen is unable to be here, because I know it expresses the very feeling he would express. Judge Long was Juvenile Court Judge of King County, Washington, for over twenty years. He has handled over 45,000 juvenile cases so far.

He says, "As a result of that experience, I have come to the conclusion that most youngsters go wrong simply because they don't have anything else to do. City kids don't have the chores to do that most of us had when we were growing up. It is more difficult for them to get out into the hills and on the waters and in the mountains. Paved streets and alleys are not very wholesome places in which youngsters can give vent to their abundant energies and their hungers for adventure.

"Many of them turn to stealing cars and burglary for their outlets."

And the last paragraph is the important one. "It has been my observation, however, that these same kids respond naturally when given an opportunity to hike and fish and climb, and I cannot recall a single case in twenty years of serious juvenile conduct in Seattle involving a youngster whose hobby and recreational outlet was fishing, and I imagine the same would go for some other things.

"But this conservation is important. It is not your soil. It is not your fish. A fish is just a piece of meat with scales on, but a fish with somebody chasing it to get away from trying to keep up with the Joneses—that is something pretty important."

Conservation is for people, and you folks have certainly stressed that.

Does anyone have something to add to this?

MR. GORDON H. SMITH (Missouri Conservation Commission, Jefferson City, Mo.): For a period of three years, now, it has been my good fortune to attend all these national and international meetings, and without exception, those of us who are professionally employed in education and information catch accumulated hell for our failures here, there and the next place.

Inasmuch as I do this thing, I do recognize that some states are limited because of money and personnel, of course, and hence are unable to do the job they'd like to do. I envision in my own mind that the average state administrator wants to do this job, but I do feel we are a little muddled in our own thinking when we talk about conservation education in its most honest sense.

We are talking about work with schools, with youngsters from the first grade through college. We are talking about our work with organized, disciplined groups, where we can get them in a room and get them seated. I might say that works. I might say, further, that it is necessary to have people who know their targets to work on those targets.

When we work on the educators in Missouri, we use a staff of nine people who are former teachers. They have backbrounds in science, in education; they are sympathetic with the educator's point of view. They work with them. They take them where they are at the present time, and try to bring them to our position—a wiser use of all the fundamental resources.

This panel has pretty well discussed ''information.'' We have an information staff, also. We use shotgun techniques, the mass media, when we are working on this large, heterogeneous population that every state has. When you work on the masses, you use mass techniques.

We use radio. As a matter of fact, I am rather proud of the fact that we are currently running 40 weekly radio broadcasts. We have two TV programs. We have press releases. And for the gentlemen of the press—with whom I have no fight, because I was one of them a few years ago—we find that 8 per cent of our press releases are in use, either completely or in part, every week. We use movies. We use slides. We us everything that we can within the bounds of our budget.

I think it is a bit unfair to condemn these people who are trying to do a job but who just simply do not have the money or the personnel to get it done. Fortunately, in our state, because of the organization, because of the constitutional rights that we have, we can do the promotional job that we have.

I think the people on the outside can help us by working through their state agencies and saying to them that they should get capable people to get the job done. We know it is a tremendous challenge. We think it is a thing that will never end, as the last speaker said.

As professionals, we think that one of the basic things we have to have is patience. It is a reeducating process. I know in my travels all over the state of Missouri, nine times out of ten, when you get up and are introduced as a conservation speaker, the connotation of the word, to most people, is ''Huntin', fishin', and the damned game warden.'' Well, very definitely, you recognize that we have a long way to go to bring them back.

Lastly, may I say that the most refreshing thing that we get out of our job is the attitude that is being created in the minds of youngsters. They don't talk about habitat, but they talk about skinning fence rows, and they do it in their art and music. It's a very fruitful field, but it takes patience on our part, on the part of the professionals. It takes far greater patience on behalf of the general public, and sometimes we are just a little bit itchy to get going faster than we are able to take them.

DR. ESCHMEYER: Gordon, if there has been any impatience in Missouri, it hasn't been with you folks. It is certainly an example to all of us. I'm amazed at the way that Missouri is going ahead.

MRS. E. F. BYERRUM (Conservation Chairman, General Federation of Women's Clubs, Illinois): The organization which I represent is a group of amateurs. There are very few experts among us. We have very little to contribute to material for an educational program. We are purely consumers.

So far there are still large groups of women who feel that conservation is not their field, that it is entirely within the men's realm, but when it is pointed out to them that their own welfare, the heritage of their children, depend upon the wise use of our natural resources, they begin to demand information, and I think they form an important group.

In the first place, they have in their hands the early education of their children, when the patterns of their thinking and acting are being set. It is too late when they get to school. They need to have instruction in the use of the land; their love of the land needs to be fixed before they go to school, and women certainly have that in their hands.

Then I think we should point out that there are in the United States today more than a million more women voters than there are men. They are an important group on that account.

It is said that women can have a great influence on public affairs, especially if you want the affairs made public, and I believe it the responsibility of you administrators to see that the affairs which are made public by women are the right ones.

MR. J. R. HARLAN (Iowa Conservation Commission, Des Moines, Iowa): I have enjoyed it for many years. The consensus at each of these programs has been that we must do a better job of conservation education and information. As a result, I am reminded a bit of the late "Ding" Darling's speech of many years ago, when he said, "Conservation is like a bowlegged girl. Eeverybody sympathizes with her, but nobody invites her to the party." Since that time, conservation has been "invited to the party," but conservation education has not.

Your figures earlier in this meeting, Dr. Eschmeyer, indicated that on a national basis, the state education and information budgets were 3 per cent of the total departmental budgets, that is, in the state departments. I would like to remind you, ladies and gentlemen, that it is money that makes the mare go.

MR. ALF LARRSON (Hayfield, Minn.): I would like to say that for three years I was a chairman of the Educational Committee on the National Association of Soil Conservation Districts, and I would like to convey, perhaps, some of the information and some of the ideas that we received.

The first year I was on the job, we called for advisory members, as we had suggested here, and we tried to get their knowledge and information as to how to go about it. We found out a few things that I would like to tell you about.

First of all, as has been stated, conservation education starts not in the first grade but in the home. That is where you have to educate the farmers. In order to educate the farmer, you must educate the teacher. We had to teach the teachers. We found that in order to get into the local districts, we had to get into the states, and also into the various counties.

Now, there are quite a few states that are doing a good job of teaching the teachers how to sell conservation to the children.

With regard to some of these gentlemen here who claim they have not been asked, we found out that in order to have education, you have to go to the departments that provide the education. We work very closely with ours in Minnesota, with Chet Wilson, who has provided a man on our committee.

I would like to see this on behalf of the National Association, or any state association of soil conservation districts—whenever you see a meeting sponsored by them, you folks are welcome to come and offer your suggestions.

I can paraphrase a statement made by a minister, that everybody wants to go to Heaven, but nobody wants to die to get there. I'm not casting any reflections on anybody. We find a lot of intellectual support and moral support, but we don't get any active participation. That's one of the things we need.

With regard to the dealer's program—yes, it works well in certain places, but in other places it doesn't. Like Houser Davidson said, I think they will assume responsibility, and we can go a long way.

In regard to the use of conservation districts, you now have 2,585 soil conservation districts in the United States, with five supervisors, commissioners or directors. I'm sure if you would ask them to give speeches at your meetings, or give information, if you will go to the districts and find out what they are doing and what you can do in order to contribute to the movement, they will be glad to give you all the information they can.

MR. DOUGLAS WADE (Columbia, S. C.): Down in Podunkville, Everywhere State, there are various youth organizations. In Podunkville's capital I happen to be the wildlife man, and I don't very often see the forestry man or the soils man or the water pollution man or the others. However, the Boy Scout program which came up this year offered an excellent opportunity for all these resource use agencies to get their administrators and their other staff members together in a common unity, and here at this meeting we have that common unity expressed very well, but the point I'm driving at is that in Podunkville, Everywhere State, there should be at least monthly meetings whereby the resource use administrators and other staff members get together for a luncheon and a two- or three-hour discussion.

Surely, out of each month, these agencies and their men can afford to do that, and we are going to try that down in our own capital, and I would suggest that very strongly. It will bring out the interrelationships that Dr. Hargrave and a good many of the other members of his panel have spoken about. It will bring out a joint unity which will develop an ecological conscience, moving across the broad front of the entire resource use program. It will accomplish what Davidson does on his farm; he is a committee of one, and he acts on all of these aspects. [Applause]

DR. JULIUS M. KOWALSKI (Illinois Conservation League, Princeton, Illinois): I am very happy to see Dr. Hargrave here this morning to lecture to us on this very important topic. I would just like to add that I think you scientific men here could solicit the aid of the medical profession, for the simple reason that doctors are continually being confronted with problems of juvenile delinquency, of child development. Many harassed parents are bringing their youngsters to physicians, wanting to know how they can properly develop them, how to correct their many behavior problems.

Of course, behavior problems have been present in youngsters ever since the time of Socrates, because, he, too, observed that the children of that age were impudent, disobedient, lazy, indolent, and had no respect for their elders. That's the very same thing that exists today. Nonetheless, the doctors of the nation are being deluged continually and daily by pharmaceutical houses, from all other allied occupations and professions, with a tremendous amount of literature, much of which goes into the wastebasket, but I think that if you professional men had a committee or some such thing set up so that you could reach the medical profession, you would find a very heart-warming response from that group, financially as well as educationally, in their management of child problems and delinquency. [Applause]

MISS ANNETTE L. PFLUEGER (Pan-American Union, Washington, D. C.): I want to thank publicly all the United States conservation educators. If you only had just a tiny idea of what you have done to help the people south of the border! You have given me materials to work over, to adapt, to pass on to the Latin-American countries, and I find that I'd like to include myself among you. I am associated with a number of your groups. I can't get too active in them, simply because I don't have the time, because my area is—instead of one state or one department or something like that—twenty Latin-American countries, and that keeps me kind of busy, as you would imagine.

I would like to make a suggestion. I have talked to some of you, here and there, and among the educators there were some who seemed so horribly discouraged. I don't blame you. Heaven only knows, I know how you feel.

I'm giving this suggestion from the point of view of a person on the other side of the border. I mean I work both sides, and therefore I feel maybe I can get a little more objective about it.

You are right in the middle of it, and I think you have made progress, because you've got to that state where you are befuddled in so many aspects of it. At every conference, now, you are having a whole panel, a whole session on conservation education. You have progressed. It's coming out. But you have got to that point where so many things are happening. If you will only realize that you are accomplishing things, and try to be more objective about it. You should see what you have done, because you have really done it.

You should just get past this state of confusion that I see. I think it is discouragement that causes that, but I don't think you should be discouraged.

MR. WADE: Annette, I'd like to ask you: Is the conservation education work of the Pan-American Union going to continue, or is in being abandoned?

MISS PFLUEGER: I didn't want to say anything about that. It is. The whole Division of Agriculture and Conservation of the Pan-American Union is being abolished as of June 30, 1954.

MR. WADE: This is something that all of us should know. The Pan-American Union, as of June 30th of this year, will abolish the conservation education work. Annette has been carrying that program almost single-handedly, and she has been feeding that stuff to the twenty Pan-American countries. I don't quite know how each of us, as individuals, can assist in bringing some sort of light to bear on this situation, but if any of you can help, I would suggest very strongly that you do your darnedest to make impressions in the places where I'm sure they will help.

MISS PFLUEGER: Thanks, Doug. I want you people to know this, that my work, as I say, has been conservation education for Latin-America. There is only one job of conservation education for Latin-America in the United States, and that is the job that I've got. Well, if that is going to be abolished—not "if," it is—there will be no one else working. I mean if there is someone else, I'd really like to know who it is.

There will be no more conservation education work for Latin-America done here in the United States, and the people there need it.

You people talk about working at the beginning stages, but what you have is something they don't have. They don't know how to do these things; they're just learning. They learn from materials we send there. What I'm after is ideas and suggestions from those of you who are interested in spreading information down there. I have to get a job, sure, but I'm not out for a job, and I'm not out for a conservation education job. I'm out to create a conservation education job for Latin-America. That's the thing I'm after.

QUESTION: Who decides this?

MISS PFLUEGER: That was decided by the Inter-American Social Council. It stemmed primarily from the Finance Committee. They feel that agriculture has not been properly handled for some time, and that work could be carried on at the Institute of Agricultural Sciences in Turrialba, Costa Rica, and it can, of course.

I had a long talk with the director of the Institute, and he says they cannot do anything more than they are doing, because they don't have the money. Anyway, they are not going to do conservation education. I failed in one respect, I think, in that I have not been able to sell the Council on conservation education. I can't even sell them on conservation, let alone the education.

I feel I was held down simply because I had no staff, and I was fighting personality obstacles along with that. Now I feel that there is an opportunity for doing conservation education for Latin-America, and if I can find it and get going here, I can really go to town.

So that is what I'm after. Of course, I'll have to take a job, but I'm going to work toward this thing.

So that is what I'm after. Of course, I'll have to take a job, but I'm going to work toward this thing.

MR. KENNETH M. MAYALL (Department of Planning, Toronto, Ontario): Three small points. In the first place, I do think we undervalue the power of women. If this is a panel of conservation education, there should be at least three women on it. In the second place, most sportsmen, in my opinion, are not members of organized clubs, and are not reached by the ordinary methods of the ordinary magazines and journals. The way to reach them is perhaps through their wives and through their children.

In the third place, if sportsmen (as we suggested by somebody) are really the dominating force, or have been the dominating force in conservation education, I think that is a bad thing. Obviously, the dominating force should be the farmer and the rancher, and his wife. That is a fact.

I would like to give you one example of what can happen. I rang up the head of the broadcasting corporation, publicly owned in a city of over a million persons, and asked him if he had any concerted plan for a television program on all phases of conservation, and he said he had none. I asked him why not, and he said, "I'm waiting for one. I have the technicians, I have the script writers, I have the television truck which can go out and bring in the material, but I do not have the plan to go to work with."

I mean, of course, a plan which would integrate land use, forestry, soils, wildlife and recreational land use. I think there is some food for thought in that.

DR. ESCHMEYER: Thank you, sir. I tried in a cold-blooded way to rate these different states as to progressiveness, and nobody has ever seen that rating. I tried to rate them in strength of numbers of organized sportsmen. I'm not going to try to discuss that further. It would be discouraging.

Sooner or late, the states must have organized sportsmen, in big numbers. Well recognized groups should be the most progressive. As I say, we won't pursue that further, but don't let anybody believe that the future of conservation rests solely with organized sportsmen. They form one important factor, and only one.

MISS PFLUEGER: I'm sorry I overlooked something a minute ago which I wanted to say. Those of you who attended the banquet last night met this gentleman through his introduction there. He was introduced as the Director of this Insitute of Natural Resources. I would like to introduce Latin-America's most outstanding conservation editor, and that has been his work, primarily. He is here in the room today. Dr. Enrique Beltran.

DR. ENRIQUE BELTRAN (Inst. Mex. de Recursos, Mexico City, Mexico): We have been very much interested in the various aspects of conservation education. The Mexican Institute of Natural Resources has carried on a series of things in that respect, concerning conservation education. First of all, we cooperate with the International Union for Protection of Nature in UNESCO, in adopting for Mexico a scheme of conservation lectures for primary schools, which has been distributed to all the countries, with the idea that each child in any country should have the same fundamental principles of conservation. That has been translated into French, German, Greek, Spanish, of course, and Italian and other languages. Then we have been printing several kinds of material which we have found very useful for education in conservation.

Right now we are working on translating into Spanish that booklet written by Dr. Palmer, who has also been under the auspices of the International Union of Protection of Nature. This is going to be available, too, for the Spanish-speaking people.

Beside that, we have a conservation course for teachers in high schools. Now all people in Mexico who get licenses for teaching in high schools must follow that course in natural resources conservation, and we are very hopeful of the results of that course.

MR. C. JACK PRIEGEL (Wisconsin Conservation Department, Chippewa Falls, Wisconsin): I am a conservation officer. As I see it, we have had explanations of whom to educate, and where. We have taken it into the home, we have given it to the kids, we have given it from the colleges and the universities, but we have failed in one place, and that is ultimately a very important place—in our courts.

With all our technical information, scientific programs and practices, we eventually have to come to legislation, and legislation then becomes law. Then you have the violators. That gets back to the game wardens or conservation commissioners or whatever they may be called.

I heard someone mention here a short time ago that "It's the doggone game wardens." Well, sometimes our juries are not conservation-minded, and as a result we suffer. Game poaching has increased. I think each state represented here will tell you that arrests have increased.

I think it is very important for you people, as educators, to carry your program into the courts, and we will have better conservation, forestry, game management, water control and everything else.

MR. ROBERT WINGARD (Penn State University, State College, Pa.): The agricultural extension services in a number of states—specifically, about a dozen of us—had an opportunity to get together yesterday for the first time that this has ever occurred at one of the national conferences. We had a discussion of many of the problems on which we are working, so far as the agricultural extension service is concerned. One of the most important problems that we run into in trying to set up the program, of course, is that first we must educate our county agent as to the services that are available through the land grant colleges before the agent, in turn, can incorporate that into a county program.

MR. SMITH: With respect to the courts, every judge in the state of Missouri, irrespective of level, gets our magazine. I assume it is read, because we check every story, and it's written for eighth-grade level, so we feel reasonably sure that the material therein is good. That can be questioned, of course, but it is readable. It may be a technique that you fellows haven't used. We can, because our circulation is free to residents in the state.

MR. LARRSON: There is another vehicle we haven't used, and that's the churches. As you know, the churches are reviving the custom of celebrating what they call Rogation Sunday. If you are familiar with the Bible, you know that Rogation Sunday is the day for thanksgiving to God for the wildlife and fruits of the earth. It is usually celebrated in May. Now the churches are calling it Rural Life Sunday.

Last year I was instrumental in getting one of our ministers to preach on a national hookup on Rural Life Sunday, and I believe if we could keep that up, once a year, it would be a good vehicle to use in getting conservation into the homes and into the churches.

MR. FRANKLIN DUGAN (West Virginia University, Morgantown, W. Va.): I hoped Bob Wingard would go a little farther when he was telling about the extension specialists in wildlife management. I think this is one group that has been entirely overlooked in the papers this morning, and I think it is one of the most promising we can work with.

It has been brought out in several cases that production of wildlife depends primarily on use of the land, and therefore on people who control the land—in other words, farmers. There is a vast organization of agricultural extension workers who are accepted throughout the country by farmers and can work more effectively, perhaps, than any other single organization in influencing the thinking of those farmers, but only on a mere handful of those agricultural extension services is there anyone employed to educate farmers in wildlife conservation.

I think that people who do work with the extension services can often be of more help, actually, in putting across the principles that the conservation departments want to get across to farmers than anyone in the employ of those state departments. In other words, their information is viewed with less suspicion by the farmers than that of someone who works for the state conservation department.

In those states where extension wildlife specialists are not already employed, I think it would be a big help if those of you in conservation education work would create a little pressure demand from sportsmen's groups, farmers' organizations and anybody else you can get in the movement to demand the employment of wildlife specialists for your agricultural extension services, to help you in your job of selling wildlife conservation to agriculturists.

MR. LYNN CALLAWAY (Department of Conservation, State of Illinois, Springfield, Ill.): This gentleman's remarks about the soil extension service reminded me that I would like to tell you that here in Illinois our director last year started a series of schools for farm advisers. We had two such sessions last year at our school, and we are planning on two more in May.

We have the county farm adviser and a few of the farmers, and some men from the University of Illinois come in with them, and we explain the complete workings of the Department of Conseration, explain the services that we offer to the farmers. Many of them tell us this is the first time they have ever had any direct contact with conservation organizations. It is very popular, and we are hopeful that we will make great strides in getting our message over to the farmer through these farm service advisers from each of the counties.

NATURAL RESOURCES—WHOSE RESPONSIBILITY?
Appraisal of the 19th North American Wildlife Conference

A. STARKER LEOPOLD
Museum of Vertebrate Zoology, University of California, Berkeley, California

We are assembled here to exchange ideas on the management of wildlife. This annual communion of minds, planned and arranged for us so faithfully and so well by Pink Gutermuth and his work crew, is a time of reappraisal, of looking back and looking ahead, of seeing a new horizon over the ridge we climbed this past year.

Every person who attends these meetings must of necessity make his own appraisal of the program. But one of us each year is asked to share his view of the horizon with the group. This time the privilege falls to me.

I will not apologize for my inadequacies in attempting so large a task, for I find in looking over the Transaction that this approach has been pretty heavily exploited by those who preceded me. Also, my predecessors have beaten me to the observation that an unbiased assessment of the wealth of material presented at one of these meetings is impossible for any one man. There is nothing for it but to give you my best.

I would like to discuss in order, three principal aspects of our collective endeavor; namely, (1) research, (2) wildlife administration, and (3) wildlife as part of the bigger problem of land use and population growth

Research. A considerable majority of the technical reports offered at this Conference can be classed as "management oriented." That is, they concern subjects of direct and immediate importance to administrators. And that of course is as it should be. Inventories of fish and game stocks and likewise of habitats are of continuing importance. Studies of yields and of population responses to hunting and fishing will be the basis for future regulations. Techniques of improving habitat will be the basis of future field programs.

As regards fisheries management, the reports by Bennett of Illinois, and by Cooper and Schafer of Michigan shed additional light on methods of producing a maximum catch of warm-water fishes. I have been genuinely impressed with the recent progress in lake and pond management. Research has shown that close regulation of fishing is not necessarily in the interest of the fishery. Good management of the water, coupled often with very heavy fishing, yields the greatest creel take and, of course, the maximum recreation. Nor is this advance limited to academic study—results are being widely and successfully applied. Hatchery costs are coming down where they belong. My hat is off to this group.

Trout are something of another story. Shetter of Michigan shows that there still may be advantages in closely regulated angling. Others have demonstrated the futility of dumping fingerlings and fry into already stocked waters, but hatcheries have not been generally curtailed. Rather a shift has occurred to catchable-sized trout, released on a put-and-take basis. The economics of this question, financed from general license fees, remains doubtful in my mind.

Pfitzer of Tennessee demonstrates a conversion of the fish fauna below big dams from warm-water to cold-water forms, a phenomenon that has been observed as well on other impounded rivers. Often a fishery is created where none existed before, as on the Colorado River. There may be some compensations in big dams.

Surveys of status and movements of various marine fishes, are reported by Raney of Cornell, Graham of Massachusetts, Roedel of California, and Atkinson of Washington. The recreational value of coastal sports fishing in New Jersey has been measured by Younger and Hamer. Reports of this nature will directly influence administrative programs for salt-water and anadromous fisheries in coming years.

No recent Conference has been offered a first-hand report on the status of the Alaska salmon fishery. The runs are still decreasing, due apparently to tremendous pressure by the fishery. Perhaps conservationists as a group could help if they were let in on the facts of the matter.

Future game programs will be enriched by an even greater number and variety of pertinent studies, reported here.

Surveys of wildlife parasites and diseases are always interesting and of potential importance. Thus Hunter's findings on lungworms in Colorado bighorns may further open the door to controlled shooting of this erstwhile protected species—a move of which I am much in favor. The principle of regulating big game numbers to protect the animals from food competition, starvation, and disease should apply as well to rare and localized species as to the common ones. Wood's report on rabies in the Southeast is a valuable supplement to recent studies of the disease in Ohio and adjoining states. The investigation of duck sickness in Manitoba by Bossenmaier and associates indicates that this most damaging of waterfowl afflictions may be even more complicated than straight botulism, which is complicated enough.

Speaking further of waterfowl, habitat surveys by Fredine of the Fish and Wildlife Service, breeding ground observations by Stirrett of Ontario, and notes on migration by Grieb and Boeker of Colorado are all of value. Dillon and associates from Delta offer some very practical observations on crop depredations and methods of control. For some years I have looked for, and not found, boiled-down summaries of the annual breeding ground surveys and winter inventories. These form the basis for the annual regulations, we are told, and as such they should be available to everyone. I speak of the summarized data, by species—not just the conclusions drawn therefrom. Likewise missing from any recent Conference has been a report on the management of the Canada goose population of Horseshoe Lake, Illinois. I personally would like ressurance that this exceedingly difficult problem is being solved.

Among upland game species, the bobwhite of Florida is shown by Frye to respond to artificial feeding, a technique formerly used mostly in colder climates. Whether the cost will permit wide use by public agencies is questioned by Frye himself. Swank of Arizona demonstrates that Gambel's quail can withstand heavy shooting without suffering general decrease. This report is significant, coming from a state that has been particularly conservative in its hunting regulations. The surprisingly high carrying capacity of coal striplands for small game in Ohio is pointed out by Riley. Seemingly the loss in soil fertility is compensated by the absence of competing agricultural uses, such as grazing. Eklund summarizes the efforts to preserve or restore wildlife habitat around impounded reservoirs, a worth-while undertaking but hardly a substitute for the inundated bottomlands.

There is only one paper on cycles, that by Buckley of Alaska summarizing historical trends in small game population of the Territory. The subject of cycles, most baffling of enigmas in wildlife biology, is actually being investigated much less now than it was a decade ago. Are we giving up on this subject just because it was not solved by the first flurry of studies, most of them short-term? The exceedingly interesting series of cycle papers that appeared in the last *Journal of Wildlife Management* highlights for me how little penetrating field research is going on. We are tending to sit back and argue the problem on the basis of theory, more or less in the manner of the old Royal Academy of France. Irrespective of whether cycles are synchronous or random, they occur locally at predictable intervals, and they must have a *biological* rather than soley a mathematical mechanism. No one has investigated to my satisfaction the possibility of fluctuations in nutritive value of the forage consumed by cyclic species. Until this is done, I fail to see how the debate can be resolved.

In the big-game and fur panel, Fletcher and Hawley of Montana offered some good biology of the marten. Yeager and Hill of Colorado depict very well the flaws inherent in overprotecting beaver, a situation parallel to that of deer and other animals capable of destroying their own environment. Robinette and co-workers in Utah have applied objective measurements to some of the census techniques that all of us use, in this case the immediate problem being to count winter-killed deer on the range. And two interesting reports of far-away animals and places were offered by Tener of Ontario, on musk-oxen, and Johnson of Montana on the game ranges of Kenya Colony in Africa.

Most of the research reports reviewed so far I would class as more or less "management oriented," as stated previously. That is, they are the bread-and-butter, fact-finding studies that are grist for the management mill. It is the cumulative volume of this type of investigation that serves to guide administrative programs along productive lines. But there are always a few studies reported that are concerned largely with ecological principles. Among the papers here I am singling out four for special attention, although a number of the reports already mentioned touch upon basic principles in some degree.

Dale's observation on the relation between pheasant distribution and soil calcium is potentially of tremendous significance. Every species is acknowledged to have tolerance limits to extremes of temperature, humidity, and other obvious environmental factors, and we known from work in Missouri that soil chemistry (*e.g.*, fertility) has strong effects on population thrift. Here is one phase of soil chemistry that actually may be limiting for the pheasant.

Along the same vein, Martin's correlation of eelgrass die-offs with periods of drought and resultant increased salinity of estuaries, may shed much light on an otherwise inscrutable problem. If upheld, this concept can become a basic part of our thinking in managing brant populations.

The paper by Spiegel and Reynolds on nutritive value of dogwood and rose fruits for pheasants was the only report, outside of Dale's, that specifically concerned qualitative nutrition. I think that we need much more work along this line.

Scott's mathematical approach to population dynamics I found especially interesting. It is the sort of thing that is bound to catch the eye of a teacher, of course, for it has good possibilities for classroom use. But more that that, a clear understanding of rate of productivity and population growth is immediately applicable to regulation of the kill. This type of thinking is drawing wildlife management out of the realm of tradition and opinion and more into the sphere of objectivity.

Research of a basic nature, exemplified by these papers, may be said to add to our *knowledge capital.* Applied studies are in the nature of *interest* that accrues from the existing body of ecologic knowledge. I have expressed before my firm belief in the importance of pursuing basic lines of inquiry, along with the immediately practical, to build up our capital deposit of general savvy.

WILDLIFE ADMINISTRATION

Wheras research reports offered at these meetings probably gives a fair cross section of work going on, the field of administration is never so completely represented. Much of the recent progress in wildlife management is of an organizational nature, not well suited to general discussion. And, of course, the administrators do much of their note-swapping at other meetings, such as the International Association of Game, Fish and Conservation Commissioners. Nevertheless, in the General Sessions certain facets of the administrative problem are usually aired, and that was the case here.

In this afternoon's panel we heard some of the latest thinking of administrators on problems of waterfowl management. The exceedingly difficult job of providing adequate habitat for ducks and geese, of preventing agricultural damage, and of balancing the kill to production is being attacked skillfully and well by state, provincial, and national governments together, with considerable help from private conservation organizations. I do not mean to imply that the problems are all in hand but rather that the approach is sound and healthy. Results of research and field surveys are in general quickly applied. I wonder if perhaps the joint responsibility of state and federal agencies is not one of the basic reasons for this progress. If the Fish and Wildlife Service "goofs off" on some matter, they hear about it from the states in a hurry. And vice versa. There are strengths as well as weaknesses in split responsibility.

The one aspect of the waterfowl problem that worries me is our apparent neglect of some of the smaller and less esteemed species. The conversion of most of the marshland of mid-latitudes into cropland has favored the adaptable grain-eaters (mallard and pintail) and the grazers (widgeon and geese). The marsh-feeding teals, shoveller, gadwall, redhead, and their kin have suffered disproportionately. Now, to protect agricultural crops from the former group, we are in many places converting the remaining refuge marshes into more grainland to attract and hold the abundant migrants. Likewise in the Pacific Flyway we have rather generous bag limits to take the full harvest of sprig and widgeon. But in effect this brings more gun pressure to bear on the little ducks, whose habitat is shrinking, even on managed areas. What is to become of them? In solving one management problem we may be creating another.

Modernization of state programs for resident game is progressing, but not at the rate of the waterfowl program. Great strides have been made, of course, but there are still curious lapses which are not usually brought to the floor for discussion at these meetings. I might point to the slowness of a great many states in relinquishing their game farms. Transactions of these Conferences for the past 15 years are peppered with papers establishing the biological futility and economic folly of liberating game from pens. We had one such paper this time, by Bowers of Pennsylvania, on restocking cottontails. But how many states have curtailed this type of activity? Very few, as far as I know. For some reason, much more progress is being made in overhauling fish hatchery programs in line with sound biological practice.

Likewise the wastage of funds on unneeded predator control continues much as in the past. Research has shown again and again how little this expensive activity adds to the hunter's bag. Arnold's report from Michigan repeats what has been learned in nearly every other state. And yet I am unaware of any general diversion of funds from control work to more productive lines of endeavor.

Most deer states have set about trying to correct the problem of underharvest. But real progress is still spotty. In far too many places opposition of the public has been stronger than the determination of administrators to regulate the herds. Papers recounting how excess deer eat up the ranges used to dominate the big-game sessions of these meetings. Now that matter isn't even news. Only one paper here, by Graham of Michigan, brings out some additional details of alteration in the forest caused by overbrowsing. Yet in recent years very few buck-law states have become deer-management states. And even in the latter group, herd control tends to be timid and partial.

I complain of these shortcomings with a full realization of the public relations problems which they entail. I have stood before many a hostile sportsmen's club and argued for doe shooting. Likewise, I was on deck when Irwin Bode and Arthur Clark abolished the game farms in Missouri. One of my duties was helping to pacify the outcry. I have seen enough to convince me that good game managment can be put across any place with enough patience, determination, and political skill.

Much of the recent progress of which we are justly proud has concerned the adoption of *new* activities based on scientific research and checked in advance by the biologists. Thus, multiflora hedges and farm ponds in the Midwest, field borders in the South, and watering devices in the arid West are highly constructive lines of endeavor.

But it should be just as much a badge of progress to shed the uneconomic activities, like game farms, bounties, and buck laws, as to adopt productive new ones. Such, however, is obviously much more difficult to do.

The lag in administrative application of research findings is, of course, always chargeable to lack of public understanding and support. At these Conferences we invariably devote some time to conservation education. There was an excellent symposium this morning on the subject. But for one reason or another we are not, in most states, supporting the educational program strongly enough to get the job done. Until we do, we can expect to continue fighting public misunderstanding and opposition to any radical departure from traditional views on management.

To sum up these comments on wildlife administration, I am in no way pessimistic or discouraged with our rate of progress—just impatient that we cannot get along a little faster. It is characterisitic of research men, of whom I am one, to traffic in free and easy style with ideas of what *should* be done, and to leave to the harrassed administrators the job of doing it.

WILDLIFE IN RELATION TO LAND USE AND POPULATION GROWTH

In our preoccupation with the details of wildlife management we are prone to lose track of the steady increase of pressure on the land, arising out of our population growth. The shifting land program may, in the long run, have more effect on fish and game populations than our best present efforts at management. Pink Gutermuth does his best to keep us aware of this bigger issue by arranging general sessions on land problems, of which we had two good ones at this meeting. I can but add some of my own reflections on this subject.

In the State of California we are becoming acutely aware of population pressures, and I have wondered at length about the future effect on fish and game. Our present population of 12 million in California will rise to 20 million by 1975, according to demographers. Even now duck marshes are being filled to make room for farms or factories. Rich agricultural flats all over the state are being swallowed up in residential suburbs. Resort areas are so crowded with cottages as to be classed as cities. More rivers have to be impounded to supply water for both industrial and domestic use. And at the same time the sale of hunting and fishing licenses is rising every year. As the demand for outdoor recreation increases, the facilities for supplying it are shrinking proportionally. How is this demand to be met?

We are fortunate in all the western states to have generous allotmenths of public land which offer certain types of recreational facilities. Deer hunting, trout fishing, public camping, and even some wilderness travel we hope will remain available to all. Arid rangelands can supply some upland game bird hunting as well. There will still be a place for the "one-gallus sportsman" to get off the road, although the quality of his sport inevitably will suffer with competitive use. Parenthetically, I may take this occasion to differ violently with the opinion of Mr. Roy Battles of the National Grange who told us Monday that public lands, including parts of the national forests, should be released for private purchase to sustain the good old American tradition of free enterprise. Whereas conceivably crops of timber and livestock might be produced as well by private as by public custodians, the recreational values would be tremendously curtailed. An agricultural economist at my university predicts that, as time goes on, recreation on the national forests will come to be the dominant use, second only to water production in social significance. We cannot afford to yield even an acre of these public lands, although pressure to do so is bound to grow as the population goes up.

Already in California free hunting on private lands is virtually gone. Hunting rights are assuming a cash value of significant importance. Many unattached sportsmen pay $10 a day to hunt coast blacktails, for example, or $5 a day to hunt ducks. This trend undoubtedly will continue. I admire our State Department for attempting to counter this through cooperative hunting areas, but I wonder about the permanence of the arrangement. Except on public lands I doubt that we can go on supplying free shooting for any significant portion of the growing army of sportsmen. And it is my impression that these developments are occurring throughout the West, and even in southern Canada, though not as rapidly as in California.

In the eastern half of the United States where public lands are much more limited in extent, the situation is even more acute. Although I am no longer in close touch with developments, I gather that payment for hunting rights is steadily increasing.

Now perhaps we are on the threshold of a new era in which a financial motive will begin to impel game management on private land. The fact that there had to be a *motive* for private management was pointed out as early as 1930 in the American Game Policy. But our early efforts to stimulate interest artificially by setting up cooperative areas on a fee basis fell flat because the supply of places to hunt still exceeded the demand. Even if hunting wasn't much good, there were lands open for the asking. This is less and less true today. Commercialized hunting is a natural sequel.

In its early stages, commercialization does not necessarily lead to management but rather to capitalizing on natural crops of game. Actually we are no farther than this today in many of the areas I am familiar with. But as income from shooting continues to climb, there will come a point where management for higher yields will follow. This is precisely the squence that has developed in private forestry, and for that matter in agriculture. Scientific management of resources seems to be impelled by prices much more strongly than by propaganda.

If I have this figured right, the initiative and the financing of game management on private lands gradually will revert from state agencies to private landowners. Which, of course, means that infinitely more management will be acomplished. This places me in the peculiar position of having to admit to Mr. Battles that private enterprise, on farmlands at least, may be able to apply a degree of management that has proved impossible for public agencies. I will admit this, freely, but I cling tenaciously to the view that low-grade sites, such as our western forests, can produce more public benefits in public ownership.

Doug Clarke in summarizing last year's Conference pointed out that in the British Isles intensive production of wildlife came only when the human population had reached a very high density. I am postulating the same ultimate result on this continent. But I look forward to it with mixed feelings. All of us want to see the land managed in such a way as to produce a maximum crop of wildlife. We are dedicating our lives to it. But the very factor of high human density which may encourage this development, by putting a dollar premium on the game, will alter irrevocably the nature of sport hunting. And, again excepting public lands, it certainly will not be free.

Commercialization of hunting almost inevitably will be accompanied by artificialization. Put-and-take operations in game farm pheasants and hatchery trout, which I criticized a moment ago as uneconomic for public agencies, may be entirely economic for private agencies a few years hence. Even state departments may find it profitable to enter this game, so long as the bill is footed by the actual consumers and not by the general license fees. Again using my home state as a prototype, we have reached this era. I know several dozen establishments where you can jerk hatchery trout out of a puddle for 50 cents apiece and several that offer pheasants, released in front of your dog, for $5 apiece.

As the current for commercialization of sport becomes stronger, we shall have some difficult decisions to make on ethical and moral aspects of public wildlife programs. The problem simply stated is this—should we continue trying to give the people what they seem to want, namely live targets and full creels at any cost? Or should we try to educate them to what we think they might enjoy more—outdoor sport with emphasis on esthetic rather than physical objective? I think it is imperative that we follow the latter course. In addition to supplying a maximum harvest of fish and game we should be striving to build up, not tear down, the esthetic value of each head of fish and game. Artificialization of sport is the antithesis of this. But future administrators will have to be strong-willed men to resist it. As I said before, the problems of the administrator never end.

To sum up, I have tried to designate a few of the peaks and troughs visible to me on the horizon of our profession. Perhaps I have overemphasized the peaks, which are always more obvious on the skyline than the pleasanter intervening valleys. May all of you find a route through the next year that sticks to the lush meadows. Until we gather again, goodbye and thank you.

ACKNOWLEDGMENT OF APPRECIATION

C. R. Gutermuth
Vice-President, Wildlife Management Institute, Washington, D. C.

Friends, we are about to close another successful Conference. As I listened to that splendid critique by Starker Leopold, I kept thinking of the complexities of such an undertaking, of the time and effort that goes into an appraisal, or summarization, of an international meeting of this magnitude. It is a tremendous task, and when I seek for words of praise in recognition for a job well done, it makes me realize that a mere expression of appreciation is inadequate.

I take pride in having started these program summarizations. If I am not mistaken, and this is entirely from memory, Dr. Rudolf Bennitt gave the first one in New York in 1946. On the other hand, the father of today's summarizer delivered that outstanding, thought-provoking appraisal at the following Conference in San Antonio, in 1947. That summary by your father, Starker, the distinguished dean of wildlife professors—an inspiring pioneer in our field—seldom will be equalled. It, like many of his writings, made history.

I have used the best words at my command in recent years in trying to praise the different summarizers for the splendid jobs that have been done. Each year it becomes a little more difficult because obviously—as evidence this one—each and every appraisal has become a little better; so all I can say to you today, Starker, is, thanks very, very much. You certainly did a grand job.

In behalf of the Wildlife Management Institute, I want to thank all of the organizations, agencies, and individuals, that contributed to the success of this year's Conference.

I want to thank in particular, Lansing Parker and the other members of The Wildlife Society, and all of those on the Program Committee, which, as you know, comprises practically all the national organizations. Lansing did an excellent job this year and I think that the program of the technical sessions shows his efforts.

We want to thank the press. I was so busy with seven-thirty breakfast meetings, and that sort of thing, getting to bed at two o'clock, that I haven't even looked at a newspaper, but I am sure that as usual, we have gotten pretty good coverage from the press and we want to thank the newspapers and wire services.

I want to thank in behalf of the Institute, the Palmer House and the Chicago Convention and Visitors Bureau, which furnished the personnel for the registration desk.

I believe that you agree that we had a good banquet last night. We filled this room to capacity and the musical and variety show produced by Jack Morton was a howling success, judging from the number of people that I saw wiping their eyes from laughter.

The Wildlife Management Institute staff always is glad to see each of these large conferences, and this annual task, come to an end. That also applies to a couple of other folks that I started to thank publicly a year or two ago because they really deserve credit, and as I watched those two individuals helping tirelessly again this year, their patience and their endurance certainly merit recognition. At this time I would like to ask Mrs. Gabrielson and Mrs. Gutermuth to stand; they contributed much to the success of this meeting.

The registration is down this year; even so, I do not think that the enrollment is an accurate reflection of the attendance. I don't know whether the people aren't registering or what. We must have had around 1,500 people in Chicago for the Conference and for the annual meetings of the National Wildlife Federation and the Izaak Walton League of America.

I knew something was wrong because our hotel room reservations were normal. We had 560 at the banquet, but the registration is little more than a thousand, which does not jibe with all of the other things. Of course, the attendance record is not the measuring stick of the success of these international conferences. We must weigh the program in its many aspects, the quality and character of the presentations, the panel discussions, the related meetings, and the personal contacts and interviews. Moreover, if the Conference accomplished nothing more than to give us that splendid appraisal of the trends, as was done in Dr. Leopold's summary of what has been accomplished, and where we are headed, the get-together would be a success and would pay its way in that measure alone.

I do not know where we will meet next year. I am sure that we will go either north or south. Thanks to all of you and a safe trip home. Happy landings! We hope to see all of you again next March.

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