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of the

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March 5, 6, and 7, 1956

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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 Twenty-first North American Wildlife Conference.

THE NORTH AMERICAN WILDLIFE CONFERENCES

The Twenty-first North American Wildlife Conference was the second of these international conservation meetings to be held in the Southeast. In spite of the fact that the location of the meeting required long travel for many, the total registration and attendance compared favorably with those of past conferences held in more centrally located cities. People registered from every state in the Union, from most of the Canadian Provinces, from Alaska, the Republic of China, Honduras, Mexico and the British West Indies. The annual banquet, with 648 people in attendance, was highly successful, and the huge Tulane Room of the Jung Hotel was filled to capacity. The only larger attendance at a previous meeting was that of the 1953 Conference in Washington.

In publishing the Transactions of the Twenty-first North American Wildlife Conference, the Wildlife Management Institute wishes to express its particular gratitude to Mr. John S. Gottschalk who represented The Wildlife Society as chairman of the Technical Program Committee, to Mr. I. T. Bode, director of the Missouri Conservation Commission for his thought-provoking appraisal of the Conference, and to the staffs of the Jung Hotel, the New Orleans Convention and Visitors' Bureau and the Louisiana Wild Life and Fisheries Commission for their assistance with the details of a successful Conference.

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PART I

GENERAL SESSIONS

GENERAL SESSIONS

Monday Morning—March 5

Chairman: OLIVER S. WILLHAM
President, Oklahoma A. and M. College, Stillwater, Oklahoma

Vice-Chairman: PAUL A. HERBERT
Director of Conservation, Michigan State Universtiy, East Lansing, Michigan[1]

WHAT CONSERVATION MEANS TODAY

The first General Session of the Twenty-first North American Wildlife Conference convened in the Tulane Room, Jung Hotel, New Orleans, Louisiana, at 9:30 a.m., Dr. Oliver S. Willham presiding.

FORMAL OPENING

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

Today, the Twenty-first North American Wildlife Conference opens, and I deem it a privilege to be here again to participate in the affairs of the Conference to the greatest extent possible. For the benefit of those who are here for the first time, it seems advisable to point out briefly the character of this meeting. While the Wildlife Management Institute works out the details, this is a North American wildlife *conference.* The General Session programs are developed by a committee representing many conservation organizations both official and private, and the Technical Sessions are planned by a committee from The Wildlife Society. This is, therefore, truly an international conference.

It is participated in by officials, by representatives of conservation organizations, and by individuals. Because of the mixed character of this conference and because of the many new things which come up in these meetings, it has long been customary that no resolutions

[1]Dr. Herbert served as vice-chairman in the absence of Dr. Stanley A. Cain, head, School of Natural Resources, University of Michigan, Ann Arbor, Michigan.

will be passed and no motions will be entertained. All chairmen of the sessions have been instructed to entertain no motions and to accept no resolutions, and we hope that you will bear this in mind during the next three days. Resolutions and recommendations on the topics discussed at this meeting are properly the prerogatives of the participating conservation organizations.

We invite everyone to participate in the discussions of the papers, both in the General and Technical Sessions. We also invite you to make the most of the opportunity to meet with others who are engaged in similar activity from other parts of the continent. In the opinion of many, these small meetings between men working on similar problems are the most productive events of this conference, and we hope that you will take full advantage of all of these opportunities.

A list of the related meetings and the places at which they are meeting are found in your Conference Program.

Two years ago, when we met in Chicago, I discussed briefly national conservation affairs in opening that conference. Last year, meeting in a friendly but foreign land at Montreal, it did not seem fitting to discuss our national, public problems. Today, I feel quite free to do so. I do not propose to repeat anything said in Chicago but to limit my comments to major events that have transpired since that meeting.

A number of good things have happened which made many hope that the Administration was becoming increasingly conservation conscious. Just about the time we were convinced, our hopes were dashed by another move which was definitely not good conservation or good management of the public conservation estate. First, let me review the plus side of the ledger. I will not attempt to go into detail since most of you are already informed of many events, but for the sake of the record some of the most important ones should be mentioned.

Perhaps the most important single forward conservation step since the Chicago meeting was the revision of the old 1872 mining laws. After long years of effort and agitation, the mining interests, the Department of Agriculture, the Department of the Interior and conservation groups worked out a draft of a bill which, while not an answer to all prevalent abuses of the mining laws, would, in the opinion of well-informed people, correct a large portion of the worst abuses. This bill, which was enacted, is a long step forward. It was passed because it received vigorous Administration support, the support of most of the mining industry, and of the conservation organizations.

The second important law was the passage during the first session of the present Congress of a bill authorizing the distribution of the $13,500,000 surplus Pittman-Robertson funds to the states over a five-year period. The first 20 percent of the total is included in this year's Interior appropriation bill as passed by the House.

A third important legislative matter was the inclusion by Congress in the amendments to the Atomic Energy Act and the Mineral Leasing Act of wording protecting the national parks and monuments and wildlife refuges from prospecting or exploration for fissionable material except in cases of extreme national emergency. Many people thought this also included protection from mineral leasing of any kind, but a Solicitor's opinion has nullified this thinking so far as the Department of the Interior is concerned.

Another important event has been the Interior Department's vigorous resistance to the repeated attempts of the Armed Services to take over part or all of the various wildlife refuges for their exclusive use. The resistance to the attempted invasion of the Wichita National Wildlife Refuge by the Army has been the most publicized, but the Department has resisted other efforts to invade the refuge system as well as a number of efforts to invade the national parks with commercial developments. They deserve the highest commendation for this vigorous attitude. The Army is continuing its efforts to secure the Wichita land, and if they succeed, it will be only because the Administration has overruled Secretary McKay in his efforts to defend this refuge.

Another item which deserves commendation is the program as outlined by "Mission 66" for the Park Service. While no one has had a chance to see the detailed proposed development in the individual parks, and while there undoubtedly will be objections to some items in proposed developments, the general statement of principles and objectives in "Mission 66" meets with the approval of most of the conservation groups. The Congress has included a considerably greater sum of money than has normally been available for this work to start "Mission 66" in the year beginning July 1. This appropriation is included in the bill recently passed by the House.

The Secretary of Agriculture has earned commendation from conservationists for two decisions which in many ways were crucial ones. One, the appeal of the Stearns Mining Company, asked to conduct strip mining operations on land sold by the company to the Federal Government many years ago and which is now a part of the Cumberland National Forest. The introduction of strip mining unquestionably would not only have destroyed a fine new growth of timber but would have caused serious erosion. The Forest Service turned this one down, and the Secretary upheld their decision.

He did likewise in an appeal by the Van Cleve interests to make a land exchange that would give them complete control of access to a vast area of national forest lands, one which already had highly developed recreational use by the general public. These two decisions were very much in the public interest and were widely applauded by conservation groups.

Conservationists have had two victories this past year that are worth special mention. In New York State, private interest groups were able to have a bill passed two years in succession by the Legislature to allow the building of a dam, to be known as Panther Mountain Dam, in the state-owned Forest Preserve. The issue then went to the people in a referendum to amend the State Constitution which protects the Forest Preserve. In order to prohibit the building of a to 613,000.

The second issue was a national one which is familiar to all. After a four-year battle, the Upper Colorado River Project was passed by the House with Echo Park Dam deleted and provisos inserted protecting Rainbow Bridge National Monument and reaffirming the National Parks Act by stating, "that it is the intention of Congress that no dam or reservoir constructed under the authorization of this act shall be within any national park or monument."

On the other side of the picture, however, we have to record several very depressing actions or series of actions.

First, the Department of Interior has gone steadily ahead in the process of changing the Fish and Wildlife Service from a scientific career service into a political agency. There are now four Schedule C (political) appointments in the top echelon in the Fish and Wildlife Service, and the morale in the organization continues to be low.

It is obvious, in the years that I have watched not only this service but others, that the same individual serving in a career status is a better public servant than he would be if he were subject to the vagaries of political fortunes. Renewable natural resources, such as forests, wildlife, soils, and waters, cannot be properly managed from partisan or political points of view. They should be managed from a long-time public interest basis. I want to state emphatically that the action of the Department of Interior in making the Fish and Wildlife Service more political than all but the most completely political state conservation departments is a long step backward. Conservation organizations and individuals have worked for years to get the state conservation groups out of the situation in which they were completely dominated by personal or partisan politics; now, we find our national wildlife organization which has been entirely free of such activities far down toward the bottom of the ladder.

Another serious setback was the action of the Interior Department in inviting oil and gas leases upon all but a very limited number of national wildlife refuges. While under the law, the Secretary has long had permissive discretion to make such leases, it is a matter of record that few were ever issued except under extraordinary circumstances. Some were issued in the early days by the old Land Office without the knowledge of the Biological Survey. During the years that I served as chief of the Biological Survey and director of the Fish and Wildlife Service, I cannot recall that any leases were issued on wildlife refuges, although we had many applications and much political pressure to do so. No Secretary under whom I served yielded to that pressure.

Now the situation is reversed and bids are invited. During the time that Secretary McKay's famous ''stop order'' was in effect from August 1953 to December 1955, several hundred leases were issued, while only eleven were issud from 1920 to August 31, 1953. It appears that many of these were issued without the knowledge of the Secretary, and the evidence given before the House Merchant Marine and Fisheries Committee in recent hearings indicates that many of them were issued without the knowledge of the Fish and Wildlife Service.

Many of these wildlife refuges were purchased with sportsmen's duck stamp money and others with special funds appropriated by Congress. There are less than 10,000,000 acres of these lands in the continental United States, less than one half of one percent of the total land area, and yet our millionaire and billionaire oil men are apparently in such danger of becoming poverty-stricken that this tiny fraction of the total land area of the United States must be made their happy hunting ground at the expense of the wildlife for which the land was dedicated.

It is not possible to explore for oil or gas, or to develop oil or gas fields, without doing some damage to wildlife and wildlife habitat. According to the Interior Department's own records of the abundance of oil and gas in this country, and in view of the fact that most producing wells are on a limited production schedule in order to prevent breaking the market, it is ridiculous to believe that there was any necessity or any need for opening these refuges to oil or gas exploration at this time.

This policy and the large number of oil and gas leases that have been issued are other long backward steps in wildlife conservation. The wholesale violation of the Secretary's famous ''stop order'' makes one skeptical as to how much attention will be given to the present regulations which *do* give the Fish and Wildlife Service some voice in the supervision of leases. They have nothing to say about issuing them. One thing is certain. The present regulations make it possible for the Department to issue the leases and then expect the career employees in the Fish and Wildlife Service to find ways to minimize the damage to wildlife values and to justify the leases. This has already happened at the House and Senate hearings on wildlife refuge bills. The "policy makers" responsible for this decision have been remarkably inconspicuous at these hearings, while career employees have been put forward to try to justify a policy of subordinating wildlife to oil and gas interests on wildlife lands. It has hardly been an inspiring example of leadership.

The emasculation of the Soil Conservation Service is another backward move which is mentioned here again because the obvious slow start in the small watersheds program is at least partly due to the lack of technical help in this field. The Small Watersheds Act was widely hailed as good legislation, and once it gets under way, it should prove helpful in developing sound land and water management programs. It has been severely criticized in some areas as involving too much engineering, particularly land drainage, instead of land management.

Legislatively, this is an important year. There are a number of important bills before Congress, among which is the need for renewing the Federal Pollution Control Act, which expires on June 30. A rather weak bill has passed the Senate, and following recent hearings in the House, Congressman Blatnik has introduced a much stronger bill, H. R. 9540, which deserves widespread support.

Senator Humphrey, Congressman Metcalf, and Congressman Reuss have introduced bills making it necessary for Congress to give approval before any wildlife refuge is abandoned or transferred. During the hearings on the House bills before the Merchant Marine and Fisheries Committee, Congressman Bonner, chairman of the Committee, proposed an amendment to prohibit gas and oil leasing on these refuges, giving them the same protection from such leasing as they now have from prospecting or mining for fissionable materials. Hearings are in progress, as this is written, and most of the conservation organizations are supporting the bill and the proposed amendment.

There are a number of bills similar to the old Baker bill authorizing the use of National forest receipts for recreational and wildlife purposes, now in committee. This legislation should be vigorously supported. If it is, there is a good chance of passing it.

The Senate Agricultural Committee has reported out an Agricultural Bill containing in the soil bank section many provisions that should be of interest to all persons interested in wildlife and forestry. If the bill passes, these sections may well result in one of the greatest conservation advances that has been made in many years. They have, however, been tied to a rigid price support scheme which is objectionable to some of the farm groups and also to the Administration. Just what the outcome of this will be is not known but conservation groups generally are supporting the soil bank provisions as presented in Senate bill S. 3183.

There are bills being prepared to give some control over the wholesale land grabbing activities of the armed services. These bills should merit support.

There is in preparation a new bill of interest to many. It is one creating a national wilderness preservation system, leaving the administration of wilderness areas as defined in the bill in the hands of the agencies now administering the land. It proposes also to establish a commission to present factual information regarding wilderness areas, to establish procedures for maintaining their wilderness character, and for preventing their invasion without the consent of Congress once the wilderness status has been established and approved. This bill, if enacted, may well represent a tremendous step forward, both for those who are interested in wilderness recreation and for those who are interested in wilderness wildlife and its values.

This has been a somewhat longer introductory talk than is usually made, but I felt that it was a good time to bring the record up to date.

This Conference is your Conference. We hope that you will get enough out of it to justify your time and expense. Have a good time and enjoy this unique and beautiful city of New Orleans while you are here, but also take back to your homes something of conservation value. The Twenty-first North American Wildlife Conference is now open.

FOOD, SHELTER AND WATER

ERVIN L. PETERSON
Assistant Secretary, U. S. Department of Agriculture, Washington, D. C.

None of us can see very far into the future. But we can be sure that we shall continue to need food, clothing, shelter and water. We must have these merely to live. If we have them in abundance we shall live well. If, in addition, we have a plentiful supply of the right kind of raw materials for industry, we shall live prosperously.

The history of Man, of nations, in all times, revolves around the ceaseless struggle to obtain these basic essentials of life.

Many of these basic essentials come from the surface of the earth. This is especially true for that large group of agricultural and forest products that provide us with food and fiber. These surface resources are renewable; with wise management of the soil they can be produced again and again. Consequently, our future—the future of any nation—depends in large measure on what we do with our land.

I grew up on a farm in southwestern Oregon. We lived close to the land and wrested our living from it and the waters that bordered our place. As I look back it was not such a bad background for the job I now hold. It gave me a deep appreciation of the land and its relationship to the welfare of people.

As a boy I learned to fish and hunt. I have never ceased to enjoy these activities. We share a common bond, you and I, in our love of the outdoors. That's why I am glad to be here and to talk with you. Like all good conservationists, we are concerned with the over-all conservation picture, not just our own segment of particular interest. Conservation that stops with saving and building up the soil—or with protecting and developing timber resources—or is concerned only with water—or aims only at saving wildlife—can never, as an individual action, succeed. There is proof that you realize these sound truths in the fact that you are considering conservation in its broadest sense at your wildlife conference meetings.

I am glad to see so many administrators of the state and federal fish and game departments here, joined in this common effort. The many young people here indicate that you have also made it possible for the junior members of the "firms" to attend this great international wildlife conference. Let me bid you young men welcome to a mighty important field of work. In your own job, you may be required to deal with specific lines of endeavor. Do the best job you can—but at the same time, never lose sight of the larger implications. In conservation and land use, we have to deal with broad knowledge across the entire field, including the benefits that accrue to our fellow man.

Natural resources have little significance except as they are related to the needs of people. We are concerned about natural resources because they are the basic material from which our essential food, shelter, water, fuel, clothing and recreation must come. With a growing population and an increasing need for the resources and resource material, the concept of production alone would soon lead to exhausted resources. So we must add the concept of management—of sustained yield—of perpetual use.

About half the budget of the U. S. Department of Agriculture goes for conservation and development of land, water, and forest resources. Virtually all USDA programs deal in some way with natural resources—research and education programs, credit and price programs, production adjustment and diversion programs, as well as programs that deal directly and wholly with soil, forest, and water management, use and improvement.

Directly and indirectly USDA is engaged in wildlife conservation. Most small game is found on farms. Most big game is in forests. Wildlife is a crop. It is a product of the land. The Department of Agriculture has a key position in the over-all management of land and its influence on the wildlife resource. The Department exerts beneficial influence on a lot of land, not only federal land but privately owned land as well. Our federal land management responsibilities are in the administration of national forests and land utilization projects.

The national forests provide the outstanding system of public hunting and fishing grounds in the entire country.

The Forest Service administers the national forests and land utilization projects which are located in 45 States and Alaska and Puerto Rico. The aggregate area is over 187 million acres. You know of the multiple values that flow from these lands. Over 6 billion board feet of timber is harvested annually. Some 8 million cattle and sheep utilize the forage resource. Most of the irrigated land in the West and some 1,800 communities derive all or a large part of their water supplies from these federal lands.

There are other resources and values, but I want especially to mention two that are of particular interest to this group. These are recreational use and wildlife use. Last year the recreational visits to the national forests exceeded 45 million. One-fourth of these visits were for the purpose of hunting and fishing. To say that the recreational facilities were fully occupied is an understatement. They were used to excess, creating problems of maintenance, care, sanitation, parking, fire protection, and other undesirable conditions.

One-fourth of the recreational use is directly for hunting and fishing. A large part of the remainder is associated with the desire to see, study, or photograph the great variety of game and non-game animals and birds found under natural conditions in the national forests. Good land management, as a general thing, helps wildlife. This is particularly true of the fishing resource, since the stability and productivity of streams and lakes are closely related to the health of the watershed.

On this 187 million acres of Federal land there are 81,000 miles of streams and two and a fourth million acres of natural and artificial lakes which are open to fishing. The big game resource is estimated to be one-third of the Nation's supply. These are public hunting grounds and fishing waters. All that is required is observance of the state fish and game laws and regulations. Moreover, these lands are unposted and largely unfenced. They are a major factor in maintaining the essentially American way of affording hunting and fishing opportunities for any of its citizens.

One other point warrants mention in connection with the Department's administration of public lands under its jurisdiction. We recognize wildlife as having a place on these lands. We want to do the kind of management that safeguards the food and cover conditions, and makes wildlife one of the multiple resources of these lands. In doing this, continued attention will be given to coordinating wildlife with other uses and in furtherance of cooperative work with the State Fish and Game Commissions and other groups.

The Department's program benefiting private land covers a wide field of activities.

The several agencies within the Department are all working to improve state and private lands—the Soil Conservation Service, the Agricultural Conservation Program Service, the Federal Extension Service, the Agricultural Research Service, in addition to the Forest Service. They are all making very valuable contributions to the Nation's resources. State agencies too are working to improve the resources of their respective States. State Land-Grant Colleges and Universities are doing a good job. State fish and game departments and state natural resource departments are making fine progress in the wise use of our natural resources. It would take a book to describe the work of all these agencies.

The programs of all Department of Agriculture agencies are focused on building a strong agricultural economy and a fertile land so that we can be assured for all time of adequate water, food and shelter.

One cannot logically think of food without thinking of the land itself. In the continental United States, the total acreage is nearly 2 billion. Some 400 million are used for growing crops. About 700 billion are used for grazing. About 600 million are classed as forest or woodland. A little less than 200 million are non-agricultural lands.

Significant progress has been made in appying soil and water conservation measures to the land—but the job is still very far from finished. Surveys indicate that erosion is still going on at a serious rate on about 200 million acres of cropland. About 40 million acres under cultivation would contribute more in the long run in permanent grass or trees. Because of flood water damage, we are able to use half of our best bottomland much less intensively than capabilities would permit. About 50 million acres of flat, potentially highly productive valley land are subject to overflow by floodwater. Some western irrigated land is suffering from accumulations of toxic salts and water-logging. Much forest land is over-cut, under-stocked, and yields its owners only a half or a third of what it could be made to produce. We have a great diversified country, but we are beginning to feel the impact of our expanding populations. By 1960 it may be 178 million. By 1975 as many as 210 million. We face the need to feed our increasing population and to provide them with good shelter.

Despite these problems and deficiencies in land management this Nation is producing basic agricultural crops far beyond the present needs of our people. Today we have stockpiled over 12 billion dollars worth of commodities. It is the greatest accumulation of products in the history of mankind. Its very presence is a threat to the agricultural economy of the Nation. We cannot go on at this present rate. This Administration is trying to do something about it. The Farm Bill is being hotly debated in Congress today. The fundamental features of the Administration Farm Bill are the so-called ''soil bank program'' and continuation of flexible price supports. Both are designed primarily to reduce surpluses. Both should also contribute to sound land use.

A group of determined legislators are trying desperately to break down flexible price support and return to high fixed support prices which are the source of so much of our present difficulties. If they succeed it will scuttle or make ineffective the soil bank program and surpluses will continue to mount.

Of course it is possible to support commodity prices at 90 per cent of parity, or any other predetermined level, provided Congress representing the American people, and farmers and other landowners will jointly share the responsibilities of regulating the acreage of basic crops that may be planted in order to control production and reduce the surpluses.

The controls which will have to be applied under a high fixed price support program will so reduce production that soon the little farmers will be driven off the land. High fixed supports is a program that helps the big landowners, not the small owners. The results of overproduction in food commodities might be likened to the consequences of overproduction of wildlife. When we have too many deer, the small and the weak die first. With overproduction in farm prducts, the smaller farmer loses out.

The Soil Bank Program is pointed at surplus crop control. Frankly, it is not specifically aimed at improving wildlife conditions. However, as you can understand, there will be secondary benefits to wildlife. These will include such dividends as increases and improvement of cover and food.

The Soil Bank Program is in two parts: One, known as the "Acreage Reserve," seeks to keep from production a percentage of acres within acreage allotments so as to reduce the output of allotment crops and permit reduction of the price depressing commodity surpluses now in Government hands.

The second part is known as the "Conservation Reserve." The "Conservation Reserve" part of the "Soil Bank" Program affords great opportunity to press ahead with our soil conservation objectives. There has long been a conservation problem arising from the cultivation of soils unsuited for permanent cropping. The program proposed, if enacted into law by the Congress, will provide a mechanism to retire much of the land unsuited for cultivation to permanent soil and water conserving uses. The use of the mechanism can accomplish several important things.

First of all, of course, it supplements the voluntary acreage reserve plan aimed at temporarily reducing production of surplus crops, and hence at reducing those surpluses. Essence of that phase of the program is that farmers would voluntarily reduce production below their allotted acres of wheat, cotton, corn, and rice. And in return, they would receive as compensation, certificates redeemable by the Commodity Credit Corporation in cash or in kind.

In addition, the conservation reserve proposal, although voluntary, will relieve farmers from the burden of acres they may have already diverted out of surplus crops but which have gone into other cultivated crops and have contributed, at least indirectly, to the surplus problem.

The President has said he hopes about 25 million acres may come into the Conservation Reserve Program. With safeguards in the form of grazing restrictions so that livestock producers are protected, this could be a major conservation accomplishment.

It would get much poor land out of cultivation. It would increase our supply of timber resources on the farm. It would give us the benefits of additional tree cover. And, of course, it would, as the name implies, put into reserve, protected against soil erosion and other forms of deterioration, acres which we might need for cultivated crops again some day, but which now only contribute to price-depressing surpluses.

There is one crop that is never likely to be in surplus—that is timber. When we think of timber and woods, we think of shelter.

The Department of Agriculture has just completed a Timber Resource Review, in collaboration with State agencies, forest industries, and others. This review shows that potential demand for timber products is strikingly upward. The Nation has no excess of forest land if it is to meet this demand. One-fourth of our forest land is poorly stocked, or nonstocked. Though timber growth is increasing, timber quality is declining. One-fourth of the timber cut is not being utilized at present. A very heavy toll is taken every year by insects, diseases, and by fire. Forest conditions were found to be best on public and forest-industry owned lands. Improved stocking and control of insects, diseases and fires offer excellent possibilities for increasing timber to meet our future needs. But the real key to the Nation's future timber supplies is in the hands of the millions of farmers and other small woodland owners. The expected demands of the future pose a tremendous challenge to American forestry. The potential of the land is adequate; the challenge is to manage it better and to make better use of it.

To wildlife people, shelter also means cover for escape, for nesting, and other habitat functions. In this connection, the Agricultural Conservation Program has made some contributions to wildlife conservation even though this program is specifically designed for other purposes.

The program provides farmers with incentive payments to help defray costs for planting soil conserving crops, planting forest trees and windbreaks, improving farm woodlands, and other kinds of land development.

Under this program a great deal of farm land has been placed under soil stabilizing crops and a cover that serves wildlife in many ways. The program has also come in for criticism because it assists the farmer in recovering the full potential of his wetlands and provides cash incentives for removing low-value trees from farm woods. We realize some of this work may be detrimental to certain kinds of wildlife but we stoutly maintain the right of the individual to put his land to the highest use he sees fit. It's his land. He's paying taxes on it. He is depending upon it for his livelihood.

The landowners who have a personal interest in wildlife or can derive economic gain from it naturally see that wildlife benefits.

Some folks have developed waterfowl shooting areas on their land. Such land may be more valuable for this purpose than any other. I think such use might be encouraged. Many states have waterfowl management areas for which a fee is charged. My own State of Oregon has several public hunting areas that contribute materially to the waterfowl hunting opportunities. I'm sure many of you agree with me that there is a place in the wildlife picture for privately owned shooting areas, as well as public shooting areas, just so long as good principles of management and protection apply.

Wildfire in particular is one of the greatest threats to any wildlife conservation program. For 15 years the Department of Agriculture has cooperatively carried on an intensive forest fire prevention campaign with the State Forestry Departments and The Advertising Council. This campaign is unique in Government-State and private business relationships as it has worked to the mutual advantage of all concerned without fanfare or bickering. The symbol for this campaign, as you know, is "Smokey Bear," but other wildlife friends are usually portrayed in the artwork.

The Forest Service reports a reduction in the number of forest fires from 210,000 in 1942 with a loss of 30 million acres to 180,000 fires in 1954 which burned less than 9 million acres.

The Smokey Bear Campaign is only one part of the cooperative forest protection program on State and private lands. This work is carried out by the Forest Service of the Department of Agriculture and 44 States and Hawaii under the Clarke-McNary Law. The cooperative protective work of the States and Federal Government has been building since 1911.

The program has helped protect wildlife habitat and has been especially beneficial in safeguarding fishing waters. Some wildlifers believe that some burning improves big game habitat. There is no argument as far as I am concerned, the controlled use of fire has a place in land management. But the use of *wildfire* to improve game habitat should not be sanctioned by anyone.

In this great country of ours, we use between 180 billion and 200 billion gallons of water a day. Estimated uses of water have doubled twice within the past 50 years. We can expect the total demand for water to double again within the next 25 years—perhaps sooner. We are already in a stage of competition, not only for the use of water, but for the right to use it. Many states are competing for available water supplies in some cases from sources hundreds of miles away.

Water management must start with the right land use for each acre it falls upon. In fact, water development and management are inseparable from land management and use. The water element cannot be separated from the soil element in a successful conservation effort. It was largely in recognition of these concepts that Public Law 566, "The Watershed Protection and Flood Prevention Act of 1954" was enacted.

This program should have a good effect on wildlife as it provides a pattern of land use that prevents erosion, maintains ground cover, and in areas of erosion will give a better type of land cover. It provides for areas of water impoundment and will protect the very important upstream land areas. The land treatment features of the small watershed programs are especially important in that they provide wildlife food, shelter, and improved waterways.

In the final analysis, conservation is essentially a job for individuals. The best possible Government program is not, and never will be, the full answer to our conservation needs. Government can help, encourage, pay part of the cost, and do some of the work directly—but the total job requires first and always a great investment of work, planning, money, and perseverance on the part of individual farmers, stockmen, timber owners, and other managers of our land and natural resources.

Above all, we want to avoid conservation by edict. But freedom requires of us reasoned understanding, a constant affirmation of those rights which are eternal and are God's gift to all men, and a constant vigilance that ours shall always and ever be a Government by law and not by men. Freedom without principle is license. It is proper and fitting that in the determination of our actions and the formulation of our proposals we should remember those great principles which applied have made us a strong and united people possessed of a great Nation.

Yes, ours is a big country—big in heritage—big in resources. We are the protectors and custodians of both the heritage and the resources.

In conclusion, I come back to where I started. The population of the United States has doubled in the past 50 years. We anticipate an increase of 50-60 million in the next 20 years. This means more people to feed, clothe, and shelter. It means an ever-increasing need for raw materials of all kinds. Most of these essential materials must come from the soil, produced through our own efforts. We have not always treated our soil resource wisely in the past. We shall need to do better in the future. This is the big job of the Department of Agriculture.

INDUSTRY AND CONSERVATION

J. E. MCCAFFREY[1]

Vice President, International Paper Company, Mobile, Alabama

I feel highly honored and consider it a privilege to be able to speak for the wood using industries at this Twenty-first North American Wildlife Conference under the banner, "Pulling Together For Conservation." The officers and staff of the Conference are to be complimented on their wisdom and far-sightedness in choosing the theme and designing this program. It enables all who have a deep interest in the conservation of our renewable natural resources to get together to expound their philosophies and discuss their problems. This can only result in mutual understanding and respect, especially where differences of viewpoint exist. This in turn, surely will ultimately culminate in the attainment of our common goal.

Certainly, no segment of our national life has a greater stake in the conservation of our renewable natural resources than the forest industries. They harvest and process for man's use the crops growing on one-fourth of our land area—our 484 million acres of commercial forest land. In using these lands, industry is aware of its opportunities and responsibilities in keeping them forever productive of wood, water, game and recreation. The wood using industries consider themselves members of the great team of conservationists which is striving for the perpetutation and sound management of all of our natural resources.

First, let me explain to you what the forest industries mean when they speak of forest conservation. I think this is necessary, for conservation means different things to different people. To some, it means locking up a resource to allow no, or very limited, use of it. To the sportsman it means plentiful game and fish and pleasant hunting and fishing conditions. To the farmer it means an abundance of rich soil and ample water. Each meaning, of course, has merit. To the forest industries, forest conservation means wise use of the forest, just as soil conservation means the wise use of the soil.

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[1]In the absence of Mr. McCaffrey, this paper was read by Mr. Harry M. Roller, Woodlands Department, International Paper Company.

Excepting those areas kept in a wild state for research or recreation, forests are of little value to man unless they are harvested. Right here I must say that industry is not intolerant of those who advocate setting aside parks and wilderness areas, to be kept forever wild and to be enjoyed in leisure moments or studied for the solution of some mystery of nature. Our growing population needs such areas; the tempo of our daily life is rising. We need primitive areas to which we can go for a brief return to kinship with the wild. But these areas should never be so large as to be wasteful of our forest land.

Forests must be harvested and carefully managed to be a national asset. Locking up our forests will not solve the problem of assuring our country—the world's most wood-hungry nation—of a perpetual and adequate supply of wood, water and game. Proper management of the forest lands and full utilization of the whole timber crop is what the forest industries mean by forest conservation.

The industries that depend on the forest for their raw material—the lumber, pulp and paper, furniture, construction, plywood, veneer, hardboard and other industries—loom large in the nation's economy. Wood processing is the principal industry in some 50,000 communities. In a recent year the wood industries accounted for 5 per cent of the entire national income. In 1953, the latest year for which we have statistics, they manufactured products valued at $19 billion. They provide year-round employment for more than one and a half million people. Millions more work in the businesses and industries which handle, transport and use the output of the forest industries. United States per capita consumption of wood and wood products is the highest of any country in the world.

The forest industries have an investment in plants, equipment and property of around $20 billion. In order to protect this enormous investment—to be assured of the raw material needed to meet the nation's demand for wood products—the industries must own and manage millions of acres of forest land. Ownership of the land on which to grow its trees gives to a wood using industry permanence in its community, to its employees job security, and provides a stable tax base for the local government.

Forest industries own and manage about 13 per cent—62,382,000 acres—of the commercial forest land in the country. Twenty-six per cent is owned and managed by the governments—federal, state and local. Farmers own approximately 46 per cent of the commercial forest land in private ownership. It is the land in private holdings that supplies about 90 per cent of the annual timber harvest; government lands account for only about 10 per cent.

So the conservation problem with which industry is faced is two-fold: to manage its own lands for the continuous production of wood and other benefits of the forest, and to encourage and assist other private owners to do the same.

Not too many years ago manufacturers of forest products, and foresters and conservationists were seldom in agreement. Industries which harvested trees were called "despoilers," and sometimes worse, and were generally regarded as being little interested in doing anything to provide for future timber and water and game supplies. Foresters and conservationists, on the other hand, were often looked on by industry as being too theoretical and impractical.

Today the picture is changed. Industry and foresters are on the same side—industry employing foresters to grow and care for the forest crops, and foresters looking to industry for leadership in all phases of forest conservation.

Forestry has advanced more rapidly in this country in the past 20 years than in any other period in history. About two decades ago a rapidly changing economy made it possible for industry to adopt forest conservation practices as part of its regular operations. Today the wood using industries employ more technical foresters—about 6,500 of them—than any other employing group, the governments included. This number averages better than one for each 10,000 acres of industry-owned commercial forest. International Paper Company alone has almost 300 graduate foresters in the Woodlands Department.

The wood using industries take justifiable pride in their stewardship of the forest lands they own and manage. On these lands are found some of the most intensive, scientific and advanced conservation practices the country has ever had. The recently published results of a government survey of the country's forest situation show 77 per cent of industry's lands to be in a highly productive condition after harvest. The figure for government lands is 80 per cent. Of particular pride to me is the fact that the report shows the pulp and paper industry—with which I am associated—has a higher proportion of its lands left in a highly productive condition than any other class of ownership, private or government. I would also like to say that the pulp and paper industry is spending huge sums of money to manage intensively its forest land. Management expenses on lands for one paper company alone—International Paper Company—last year exceeded $5 million.

And I should like to add parenthetically that on most industry-owned tree growing areas true sportsmen and appreciative recreationists are always welcome, except in time of extreme fire hazard. For example, in many areas in which International Paper Company owns forest land we have leased specified areas to local hunting clubs.

At Georgetown, South Carolina, in particular, this plan has been very successful in making our lands available to local hunting clubs on an organized basis. Many local citizens have enjoyed hunting privileges on Company land and at the same time have helped us keep out destructive forest fires.

But the conservation activities and interest of the forest industries are not confined to their own lands. Industry must always depend on the lands of others—particularly farmers and other small landowners—for timber. Nearly two-thirds of the private commercial forest land is in holdings under 500 acres in size; the average size of these ownerships is 49 acres. Government reports indicate forest conservation practices generally are poorest on those small holdings. Industry accepts as part of its responsibility, and works side by side with government agencies, in a program of education and assistance to landowners to encourage them to adopt sound forest practices on their land. One educational project of which I am particularly proud is the Jackie Davis Comic Book program of my Company. Various phases of forestry are discussed in a story of Jackie Davis and his friends told in comic book form. During the past six years we have distributed more than nine million copies of these booklets to the school children of the South—copies being provided for each sixth, seventh and eighth grade student and all Vocational Agriculture students throughout the schools of nine southern states. I'm sure you would be interested in knowing that last year's booklet featured the relationship of forests and wildlife. The center spread of this book was reproduced in poster form and a supply of these posters have been made available to the Fish and Game Commission people in each state for their use.

Most notable of industry's conservation education and demonstration efforts, perhaps best known to all of you here, is the Tree Farm program. Now active in 40 states, the American Tree Farm System had more than 7500 certified Tree Farms on its rolls at the beginning of 1956, embracing approximately 38 million acres of well managed privately owned commercial forest land.

A tree farmer earns his Tree Farm certification by demonstrating an ability and desire to protect his forest and to manage it for repeated crops of wood and other benefits which result in watershed protection, preservation of the soil, maintenance of forage for game and recreation. Multiple use is an inherent part of tree farming.

Many industries are taking more direct measures to stimulate the adoption of better conservation practices on small woodlands. Some individual firms and several industrial associations have foresters who spend all or part of their time assisting small woodlot owners in their forest management problems. The work of the Southern Pulpwood Conservation Association in the southern states is an outstanding example of this. The SPCA is supported by pulp and paper companies and pulpwood producers from Virginia to Texas. In Wisconsin another organization of the pulp and paper industry, "Trees For Tomorrow," is doing similar work.

In many sections of the country individual wood using industries have formed Tree Farm Families. These are groups of small woodland owners whose lands are managed for them by company foresters, without charge. In return, the owner agrees to give to the company first chance to purchase stumpage at prevailing prices. The agreement is usually verbal and voluntary and is not binding on either party. Industrial Tree Farm Families are organized and operating in Georgia, Maine, Pennsylvania, Mississippi, Ohio, Alabama and Tennessee. Others are now being organized in other states.

A major concern of the forest industries, as of every forester and conservationist, is protection of the forests from fire. In spite of the remarkable progress in reducing fire losses over the years, fire continues to be one of the most urgent problems confronting industry, particularly in the southern states.

To supplement and strengthen the forest fire prevention activities of the federal and state forestry departments, the industries finance the effective "Keep Green" campaign in 34 states. Forest protection is a cooperative project, one that demands the combined efforts of industry; government and the general public. Industry particularly seeks the cooperation of sportsmen, for the pursuit of their recreation generally takes them to the forest in times of high fire hazard. In this connection, I should like to quote the words of Mr. Ernest Swift from an article entitled, "Fire In The Woods—The Sportsmen's Responsibility," which appeared in the December, 1955, issue of *Conservation News.* Perhaps most of you here have read it, but the appeal of Mr. Swift is so well put and so timely that it bears repeating. I quote:

"The sportsman-leadership in many states has been slow to realize that stopping fire in the woods is a greater civic responsibility on their part than promoting their favorite recreation. In this regard there is a wide variance of understanding. Enlightened sportsmen admit fire is damaging to wildlife interests. Some will extend their perception to community prosperity based on watershed protection, forest industry and payrolls.

"Here is an opportunity for a teamwork job where sportsmen's organizations can participate. In many communities timber is the backbone of business. It is the difference between ghost towns and prosperity; it helps fill dinner pails, sends children to school, pays off mortgages and, in conjunction, produces revenue from hunting, fishing, skiing, dude ranches and resorts.''

Speaking of the teamwork between sportsmen and industry, I would like to tell you of an excellent example of this type of cooperation. To improve the area into which the waste water from the International Paper Company's two Bastrop Mills was discharged, the Company built a large water impounding basin. This basin is a natural habitat for ducks and is considered one of the finest duck hunting areas in the state. We have welcomed hunters to use our facilities on this 5,000-acre basin and the popularity of duck hunting can be judged by the presence of over 700 cars counted there on the opening day of duck hunting season. The hunting was good too—more than 2,000 ducks were killed that day!

Protection of the forest from insects and diseases is a concern of industry, too. It is one in which the forest industries are cooperating wholeheartedly with government and other conservation agencies. Insects and diseases are many times more destructive to the forests, in terms of timber volume lost to man's use, than fire. The report of the Timber Resource Review of the United States Forest Service, released late in 1955, estimates losses from bugs and disease in 1952 to be more than one and one-half billion board feet of sawtimber.

In many parts of the country industry is cooperating with universities and government agencies in research to solve the mysteries of tree diseases and timber destroying insects, and in measures to bring them under control. Where insect or disease epidemics are in progress, the industries are bearing their share of the burden in attacking them. In some of the western states industries have completely altered their long-range cutting schedules and production patterns to salvage timber threatened by bugs.

The forest industries have long been engaged in reforestation projects on their own lands, and in encouraging and assisting their neighbors to do the same. Of course, nature does the best job of reforestation, and the harvesting methods industry uses and advocates insure natural reproduction. But where natural seed sources have been removed through land clearing, fire or other causes, it is necessary to plant trees or sow seed.

More than 1,300,000 acres of industry-owned land have been planted with trees—267,000 acres last year. In all, about 85 per cent—687,000 acres—of the 811,000 acres of forest plantings last year were on private land.

Many of the smaller owners who planted were assisted by the forest industries in obtaining trees or in securing the use of planting machines. This assistance to small private landowners has become a customary activity of many forest industries in all sections of the United States.

The rapid strides in forest conservation made in this country in recent years have been largely due to research in tree growing and wood utilization. In the search for better ways to grow more trees—for better tree strains, better harvesting methods, uses for all species and for all parts of the tree—industry has been the leader. Cooperating with colleges and government agencies, as well as in laboratories and on lands of their own, the forest industries are contributing nearly two-thirds of the funds spent on research in forestry in the United States.

Industry feels, and with justification, that its activities and influence in forestry have contributed significantly to the greatly improved condition of our forest resources. This condition has just been made known through the preliminary report of the Timber Resource Review, published by the United States Forest Service in October of last year. The TRR, as it is commonly known, was a three-year study of the nation's forests, led by the Forest Service and participated in by government and private agencies. It shows great improvement in the forestry picture over the past 10 or 20 years. Here are some of its significant findings:

Forest area has increased. The Forest Service Reappraisal survey of 1944 showed 623,828,000 acres of forest land in the continental United States. TRR shows 647,686,000 acres—an increase of nearly 24,000,000 acres. Some of the increase is due probably to a change in definition of forest land. Much is undoubtedly due to forest plantings on formerly idle lands. Natural reforestation of abandoned agricultural land is also a contributing factor.

Commercial forest land has increased. Nearly all of the increase in forest acreage is in the commercial classification. That is, land that is capable of supporting commercial timber crops and is available for harvesting for man's use. In 1944 we had 461,000,000 acres of commercial forest land; TRR showed in 1952 we had 484,000,000 acres—an increase of 5 per cent.

The size of our wood pile has increased. The volume of wood in sawtimber-size trees in 1944 was estimated to be 1,601 billion board feet. TRR shows we have 1,968 billion board feet. Some of the increase is accounted for by improvements made by the industries in their utilization standards. Today we can use species and grades formerly considered unusable, an indication of the success of industry's research and efforts in attaining the goal of full use of the timber crop. Much of the increase is due to increased timber growth, however.

The volume of wood in our forest growing stock has increased, too. By growing stock is meant all trees 5 inches and larger diameter, breast high. This volume in 1944 was 470,000,000 cubic feet. Now it is 498,000,000 cubic feet, an increase of 6 per cent.

To conservationists, as well as to economists, perhaps the most encouraging and significant fact revealed by the Timber Resource Review is that our forests are growing more wood than is being removed from them. For the first time in our history the annual growth of timber exceeds the amount harvested for use plus the amount lost through natural mortality and fire, insects, diseases and other causes. The growth of growing stock exceeds the removal by 32 per cent—nearly one-third. Sawtimber removal is very slightly in excess of growth, due to the fact that much of the sawtimber harvest is in the immense old growth forests of the west and northwest. In every section of the country where the old growth forests are gone and second, third or fourth growth stands prevail, the timber growth is in excess of removal.

These facts reveal the triumph of American conservation. Forestry started in this country little more than 50 years ago, pioneered by the Federal Government and later joined by the states, industry and public spirited citizens groups. The achievements reached so far we can all view with satisfaction.

But we must not rest there. We have more to do. For its part, industry accepts the challenge of growing more trees to meet the rising demands of a growing population. It will not slacken its efforts to raise more and better timber on its own forest lands and to find uses for all the wood it grows. It will continue to urge all the people to take better care of the forests to meet our needs of timber, water, game and recreation. It will continue its programs to educate youth in the thought that thriving forests are necessary for the good life. It will continue to work with and welcome the cooperation of all worthy conservation groups toward the perpetuation and sound use of our renewable natural resources. In short, the nation's wood using industries will continue to move forward with its partners in conservation.

COMMERCE AND CONSERVATION

WILLIAM A. KLUENDER
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Conservation has become a well-known and popular subject of discussion in recent years, partly so because of the broad interpretation of its meaning. To some persons, conservation has no greater significance than the pleasurable rewards of hunting and fishing. There are others, more rightfully termed "preservationists," who hold the belief that our natural resources should remain untouched by man. We in commerce are primarily concerned with the aspects of intelligent and economic utilization of agricultural, forest, minerals, and petroleum resources. To us these are basic wealth-producing capital assets. They must be nurtured into and retained in continuous and economical production.

Approximately 65 per cent of all the new wealth created in this country each year has its origin in agricultural and forest production. These are renewable or replaceable resources. The other 35 per cent comes from the mines and petroleum fields—from the so-called non-renewable resources. It is evident that as our non-renewable resources become depleted we must, of necessity, depend more and more on the renewable ones.

Transportation agencies, particularly the railroads, are vital links to our chain of commerce. Transportation provides the net which holds together the many segments of our total economy. In providing this distribution service the transporting act itself contributes nothing to the basic value of the materials and products hauled, but without it markets would be very limited. Transportation charges, therefore, of necessity are low. Imagine, if you will, an average charge of less than 1½ cents to move a ton-mile of materials and goods necessary for our daily well-being. Low-cost distribution charges are only possible because of extensive transportation systems, handling materials and products on a mass basis, by efficient methods.

High investment costs and the inflexibility of rail lines make railroads very dependent on the communities served. Communities like the ones you and I come from cannot forever maintain their economic prosperity unless they are fed the raw materials of healthy hinterlands. Where railroads operate through territory which has depleted its agriculture and timber, has exhausted its minerals and petroleum, wasted and polluted its waters, they come face to face with the realistic challenge as to what can be done to maintain freight traffic revenues.

The railroads stand alone in the transportation field as employers of technically trained personnel to work on resource development. There is reason to believe they will even expand these activities as railroad managements recognize the full potential value of developing and harvesting the resources tributary to their lines, particularly in respect to the resulting industrial development opportunities that are created. Today most of the railroads employ in one or more departments trained agriculturists, conservationists, reclamationists, foresters, geologists, mining engineers, industrial engineers, real estate agents, zoning experts, and others to handle their development activities.

The problems and resource activities differ considerably between railroads. An eastern line finds it advisable to devote much of its activity to agricultural relations with other organizations. A western line with extensive land and mineral holdings devotes its major activities to their management. A southern line operating here in Louisiana is promoting the South's reborn forestry opportunities and is capitalizing on the resulting industrial developments, paying off in what railroaders term "car numbers." Our good Canadian friends to the north still have major problems of land settlement along their lines. Their activities include the movement and complete settlement of immigrants from across the Atlantic to points along the rail lines in Canada.

I could further relate in detail how the Southern Railroad operates and manages sizeable forest properties as an example of profitable sustained timber harvesting—how the Illinois Central introduces high-quality dairy breeding stock in its territory—how the Texas and Pacific carries on a program for the prevention of perishable product losses with the growers and packers—how the Union Pacific schedules and programs its specially equipped Agricultural Development Car—how the Great Northern aids in bringing newly developed irrigation districts into production—how the Milwaukee Railroad carries on an extensive program encouraging the use of fertilizers in its territory—how the Soo Line has cooperated with the State of Wisconsin in making parts of its rights-of-way available for game bird management—and how we on the Chicago and North Western have set up a demonstration area on a tract of land we could not sell for $30.00 per acre ten years ago and are now realizing an annual net return of $30.00 an acre.

Countless other examples could be given; however, in every case it is recognizing and then doing the job that needs to be done—something like digging potatoes. It isn't so necessary to dig like Hell as it is to dig where the potatoes are.

Sound resource management cannot be done by wishful thinking. Decisions must be based on facts. Many of the rich flood plains served by my railroad, the lands from which our heavy agricultural traffic originates, are becoming the spoils dumps for eroded light soils from mismanaged upland areas. There is no easy solution to this problem. Throughout our northern territory where line abandonment surveys are almost continuously under way, depleted forest lands stand as disfigured monuments to our past land management practices. It's a fact that most of these lands cannot be easily or quickly restocked to commercial production. In our territory are silt-laden streams carrying a mere trickle of water at some seasons of the year, yet dealing destructive floods at others. It is also a fact they present a real and expensive challenge to our water conservation know-how. Communities of depleted resources and industry become ghost towns and centers of unemployment. They are ripe to accept the political philosophies that grow on misery. A healthy social, political and economic interdependency of our urban and rural societies is vital not only to commerce but the whole country.

The conservation problems described are not peculiar to our territory. They are widespread throughout the length and width of the country. Combined, they present challenging and complex situations that have led the whole field of conservation know-how into a period of transition accompanied with a generous sprinkling of confusion. The problems we face today are not too unlike those of the Sultan's son who had inherited a harem. He knew what was to be done but he was confused as to where he should start.

Although we in commerce are attacking the problems of resource management in fields peculiar to our respective needs we are in accord on basic approaches to the overall problems. I like to call them the five golden rules of practical resource management—applicable equally to the individual and our society as a whole if this nation is to thrive, let alone survive.

First, we believe that if any extensive progress is to be made in resource management it can most successfully be accomplished via the route of a profit incentive rather than through the sale of a political bill of goods. One of our big jobs is to show land owners (or managers) that conservation investments can be profitable without an extended time lag between cost outlay and returns. The conservation dollar must be able to compete with alternative uses of the owner's funds, and that holds true for public funds too. Furthermore, our real success in conservation will be determined more by what is done by private initiative on the owner's land than by public programs on government land.

We further believe extensive soil and water conservation programs will be closely tied in with our nation's agricultural program and both will have to operate under the same set of government rules. The continued use of excessive special legislation carries with it the constant threat of government control and regulation. Nationalization stands as a threat to our nation's agriculture just as it has to our railroads. Agriculture wants to and should be retained on a family-operated incentive system—an incentive to progress—an incentive to work—an incentive to install conservation practices on the land—and an incentive to be free in this wonderful approaching atomic age. We in railroads are ever mindful of the potential pitfalls of too much special legislation. Many well-intended government controls of yesteryear, meant to develop our progress in an orderly manner have long since become outmoded and can end up derailing the whole industry. The pattern and scope of our agriculture, forest, and water economy in 1975 is being shaped by the policies and practices now in effect.

Much has been said lately about our surplus crop production and the need to reduce the size of the agricultural plant. It is difficult to believe we are overexpanded as long as a pressing human need exists in this country for an abundance of goods which will improve our health and make our lives richer. More realistically we need a readjustment in land use plans. Through technological know-how we can now overproduce our basic food requirements. Isn't this an excellent time to get away from the ill-founded tradition in this country that crops must be fundamentally grain, cotton, rice and livestock? We in transportation are not fully sympathetic to warehouses bulging with crops which for the lack of markets don't become involved in commerce. On the other hand oil crops, crops high in vitamins, and forest crops, all to some degree now in short supply, enter commerce in full volume.

Isn't this an excellent time to specialize and diversify? Emphasis on trees as a potential crop is long overdue. One-third of our forest area is on farm woodlands. Timber crops can provide much needed cash revenue to the farm and simultaneously contribute real benefits toward the control of water and wind erosion. During the next twenty years population increases alone should result in a 30 per cent increase in United States pulpwood requirements. Improved techniques for wood fiber reduction has broadened the base of usable species, thereby fully assuring growers of an expanded and continued market for their farm woods. Species fifteen years ago considered next to worthless are now used in large volumes in wood pulp manufacture.

Future demands of high-vitamin fruits and green and leafy vegetables, now largely grown on western irrigated lands, are estimated from 25 per cent to 75 per cent above present levels. Dry lands presently all too limited in their productive capacities might be well suited for growing certain oil seed crops. The possibilities of chemurgic crops have hardly been explored. For example, in this country we have never produced any rose oil used in fragrant perfumes. An energetic Texan this year is importing 30,000 French rose plants to be planted on 30 acres of Texas soil, which within a few years will increase to several hundred acres.

An understanding of markets and competition between raw materials is essential to the resource manager. We in commerce, particularly in railroads, know something about competition and possibly some of these experiences are worthy of consideration in resource management. We are for competition 100 per cent just as long as each team plays with the same set of rules. Raw materials, like services and products, need to keep themselves competitive or they lose their markets. A single example is textile fibers. Although total production of fibers in the United States has been increasing, this increase has been largely in the synthetic or man-made fibers. Synthetic fiber production increased from 128,000,000 pounds in 1930 to 1,432,000,000 pounds in 1954, or more than eleven times. Over that same period wool production declined 33 per cent. In the case of cotton, one of the nation's leading agricultural authorities recently stated that at the rate cotton is being replaced by synthetic fibers we won't need many bales in another twenty years. Many factors such as prices have influenced the trend in favor of synthetic fibers. I feel certain natural fibers can compete pricewise, but if they can't, it hardly seems wise to continue a set of rules that encourages surplus production and further complicates the problem.

The final item for your evaluation is the need for more attention to zoning. Zoning is the legal tool that permits carrying out comprehensive and carefully considered land use plans. Our nation's railroads are strong exponents of zoning and employ the best men possible to direct their efforts in this field. To date our efforts have been concerned largely with urban zoning matters, with lesser appreciation of the needs for rural zoning. Our people don't like residential developments springing up in areas more suitable for industry, to name but one example.

Each year over one and one-half million acres of rural land are going out of agricultural and forest crop production. In the part of the country I come from, toll road plans now on the drawing boards will take 21,000 acres of some of the nation's best agricultural land out of production. A first-class highway takes up about 25 acres per mile and elaborate road systems up to 60 acres per mile. Airports require large level acreages within short distances from cities. Such sites are usually the best and most intensively-farmed agricultural lands because of their nearness to towns and their level topography. In the last fifteen years over 3,500 airports have been established. More than 115,000,000 acres are currently occupied by cities, highways, factories, airports, parks and railroads. These figures are not related in opposition but to point out a trend which should be of concern not only to conservationists and land use planners, but to everyone.

We are experiencing a tremendous encroachment on our best agricultural and timber-producing lands. Good lands should be set aside for farming and poorer lands designated for other uses. Zoning provides a sound basis for dividing land into residential, industrial, transportation, agricultural and forest uses. If we are willing to spend millions to save our best soils from erosion and mismanagement, then it's also time to give serious consideration to saving it for food and fiber production. Either one or the other is not enough. Both are needed, because one begets the other.

The golden rules, or essentials to successful resource management, are more than a figure of speech. We believe they hold the key to a continuous creation of fantastic wealth for the nation for centuries to come. To say it another way, we can eat our cake and have it too.

CONSERVATION AND NATIONAL WELFARE

RAYMOND A. MCCONNELL, JR.
Editor, The Journal, *Lincoln, Nebraska*

Conservation is a tremendous word, meaning just about what you want it to mean. In one way or another everyone likes to think of himself as a conservationist. Certainly no one calls himself a despoiler, or a wastrel, unless in the privacy of the confessional.

In almost any fight over natural resources—and throughout history water and soil have been fighting matters—you are likely to find "conservationists" fighting "conservationists." The conservationist who wants to store and use every available drop of water for irrigation may find himself in conflict with the conservationist who opposes the destruction or alteration of irreplaceable scenery. The conservationist who wants flood control may run head on into the conservation-minded farmer. And so on, across the whole range of values which are at stake in the management, development and use of natural resources.

I am sure you will have some lively arguments at your sessions here—all among conservationists.

Yet if we are to discuss "Pulling Together for Conservation," your conference theme, we must find some common principles or values on which there can be widespread agreement.

In any search for areas of agreement, it is usually best to start with demonstrable facts or self-evident truths which need no demonstration and which nobody can deny.

Suppose we start with a few.

Anybody can argue the relative merits of big dams versus small dams in providing flood protection. But you can't settle the argument until there is some consensus as to what is to be protected—an entire river basin including its agricultural lands throughout, or the lands and population centers downstream solely.

But—nobody can deny that a dollar's worth of upland is worth as much as a dollar's worth of bottom land, or as much as a dollar's worth of city real estate. This is a self-evident truth.

Water runs downhill. This is a demonstrable fact.

Water runs off land into streams, carrying some of the land with it. It runs from streams into rivers. These, too, are simple matters of seeing and believing.

In the light of these demonstrable facts it is evident that the management of land in ways to encourage or retard runoff is the beginning point in the management of water. It is evident too that while the problem of controlling and using water begins there it does not end there, but continues on down the tributaries, to the rivers, to the sea. Even the sea, today, as a source of usable water, is not beyond the range of the conservationist's concern.

One final truism: The place to begin is at the beginning.

By now of course you know that I have set forth the first principles on which rests the new national program for watershed development and flood protection, a cornerstone but so far no more than a cornerstone in any sound overall national land and water policy.

They are principles on which conservationists of every shade and color—bitter foes perhaps on other things—can and do now pull together. The National Watershed Congress is evidence of this. Sponsored by 25 national organizations, including all the various organized agricultural, industrial, labor and recreational interests, it has had two successful years of exploring ways to further a national policy based on such principles, and will culminate the third on Sept. 18-19 of this year in Lincoln.

Since it is a cooperative endeavor, with such diverse sponsorship, it cannot "adopt" any binding, governing, ground rules. If it could, however, I am sure from all that has been said at the first two Congresses, that these would dedicate it to some such purpose as this, with respect to every watershed in the nation:

". . . To bring to all the land and all the people of the area the protection and benefits of a complete program of on-the-land water conservation, erosion control, flood abatement, recreational and wildlife development, pollution abatement, and enhancement of municipal and agricultural water supply. . . . Objectives which are all tied in together and can best be attained when pursued together by all the people of the area and all the agencies, working together."

I know that these are practical working ground rules for pulling together, not only because they are unwritten rules of the National Watershed Congress but because for six years they have been the written rules in the charter of incorporation of the Salt-Wahoo Watershed Association of Nebraska. In the pursuit of this association's aims for an important section of Nebraska we have succeeded in enlisting the cooperation of upland and bottomland farmers, upstream towns and downstream towns, the Chamber of Commerce, industrialists on the flood plain, all the banks, and the governments of our city, of six counties, six soil conservation districts, and the state, plus the Army Corps of Engineers and the Department of Agriculture.

I might discuss the meaning of a systematic overall conservation program thus stated—one beginning at the beginning and embracing all related objectives—with classical references to the fates of long-lost civilizations whose artifacts are buried under centuries of rubble and dust because they did not know how to care for their soil or use every drop of water, beginning with the rain where it fell, for the greatest good of the greatest number over the longest period of time. Or, knowing, did not apply the knowledge. This would take us on a journey back through the centuries and around the globe, from Egypt to Ceylon, from Mesopotamia to the lands of the Mayas and Aztecs. Throughout history it has been the rule, not the exception, that flowering civilizations have neglected their soil; neglected the relationship of soil and water, and in this neglect withered and died.

But one reason for not dwelling on this is that when a nation has agricultural surpluses piled up on every hand as we do, you can't readily scare it into enhancing its agricultural productivity through conservation by threatening it with the fate of Nineveh and Tyre.

Instead we must reason together.

There are today the very best of reasons, visible on every hand, for this nation's becoming the exception among civilizations, and utilizing every acre of land within its capabilities and according to its needs, while managing every drop of water to the fullest advantage from the top of every divide on down.

To do so is in fact fundamental to the solution of some of our most pressing and immediate national problems. It is basic to the achievement of a well-balanced economy geared to the needs of a growing nation. It is basic, as well, to the pursuit of happiness. Both are aims highly relevant to the security of the nation and to its well-being.

Let me discuss the urgent immediate reasons for pulling together in a comprehensive conservation effort. Acute in the minds of many stricken people today is the realization that they and their government should have got started on flood prevention long ago.

A life, or a dollar's worth of property, destroyed by floods for example, is no less valuable than a life or a dollar's worth destroyed in war. This year any citizen of New England or the Pacific states can testify, I should think, to the urgency, as a matter of simple security, of a conservation program soundly conceived so as to include flood prevention among its aims.

Our government recognizes in principle if not always in practice that the effects of natural disasters in peacetime can be on a par with those of man-made disasters in war. It does this in designating the Federal Civil Defense Administration as the agency in charge of dispensing millions of dollars for emergency relief in the aftermath of floods, just as it is the agency to take over after a bomb hits. Yet principle and practice are still far apart. One minor fraction of one year's expenditure on peacetime disaster relief could have completed the entire Salt-Wahoo program guaranteeing an area twice the size of Rhode Island permanent immunity from this kind of hazard, while at the same time giving it much greater stability in the face of the cyclical and seasonal droughts which afflict vast sections of the country.

As with flood prevention, so is the nation's survival and growth heavily dependent on the success with which we can overcome limitations of water supply for our rapidly growing cities and expanding industry, as well as for our agriculture. Not even the atomic age has brought the automatic solution to this problem: so far in fact it has merely pointed it up more acutely. Recently a site near Lincoln was selected for construction of a nuclear reactor power plant. Availability of abundant water in that locale was the determining factor in picking the site. I assume that the spokesmen for business and industry on this panel are discussing this urgent national problem of water supply. But I can add that enactment of legislation now pending in Congress (H.R. 8750, and Senator Carlson's companion bill in the Senate) so as to bring municipal and industrial water supplies within the scope of watershed programs under the National Watershed Protection and Flood Prevention Act, is a concrete step in its solution which can and should be taken now. The small and medium-sized communities most likely to be affected by watershed programs, are as critically in need of additional water for domestic and industrial use as are the great metropolitan centers, and for the vast mid-America to which industry is dispersing for security reasons, there is no hope in the foreseeable future of piping water from the sea.

Those amendments also would permit federal assistance to local organizations in pollution abatement through streamflow regulation as parts of an interrelated watershed conservation plan. It is only realistic to recognize the inseparability of the problems of adequate water supply and of pollution abatement. In the absence of a systematic attack on it, the latter problem only grows worse as industry expands, and in turn it spells a limitation on usable supply.

I have spoken so far of problems demanding national and local attention and action today, and each calling for the application of sound conservation principles. But instead of problems you could just as well call them exciting opportunities for pioneering new pathways in natural resources management.

One such certainly is the farm problem with all its economic and social implications, a problem very much in the news, and its true dimensions too often obscured by the political haze. Let us look at it for a moment as a revolution before our very eyes. It is a revolution with profound implications for every one of us, whether we live on a farm and work in a city as I do and as increasing numbers do, or work in a city and live in a city, as do still more rapidly increasing numbers, or live on a farm and depend on it for a livelihood, as do fewer and fewer Americans every year.

It is not overstatement to describe as revolutionary the developments in agriculture over the past twenty years, and what these mean today to our urban as well as rural way of life. In that period agriculture has progressed further than it did in all the centuries since man discovered he could place a seed in the ground and it would grow into something useful. It is clear to see in history the impact that the industrial revolution of the 19th Century had on the economic, social and political life of the civilized nations of the world. The main force of the agricultural revolution is only now being fully realized. Conservation practices have had something to do with it. They have a lot more to do with how we come through it.

The agricultural phases of the 19th Century revolution were necessarily delayed until the manufacturing phases had been accomplished. This meant that it was not until the mid-1930s that these tremendous changes on the farm could begin on any scale. At first they were interrupted by depression and drought, then by war. So it was not until ten years ago that the full force of these pent-up developments was able to burst into the open. This force gives promise of still having a long way to go in this nation. In most of the rest of the world it has barely started but in nearly every corner of the globe there are rumblings of the awakening of the agricultural giant.

Along with mechanization, improved crop and livestock varieties, fertilization, and weed and insect killers, improved soil and water management techniques and the greatly increased application of them, have been factors in a 40 per cent increase in agricultural productivity in ten years. Where in 1940 each farmer produced enough to supply himself and ten others, in 1955 he raised enough for himself and 17 others. This is what is behind the migration of people from the farms, in progress since 1933. In that year 32.4 million persons lived on farms. In 1950 the farm population had dropped to 25.1 million and by 1955 to 22.2 million—down to 70 per cent of its level in 1933.

Whether government retards it or not, the trend very likely has not run its course. And the sound answer to it is not less of all the many things, including conservation practices, that have made farming more efficient, but more. The soil bank and acreage reserve proposal, which apparently has the backing of most of Congress, rests on the hope of curtailing production, as a short-range solution, by putting land into a conservation reserve. If it works, it seems to follow that as fewer acres are farmed, fewer farmers will be needed to do the job.

If production can be cut now, and the farming is done by the more efficient producers, it should make it possible to grow crops more cheaply. In the meantime, research will be developing more uses for crops. When the new uses and the lower prices correspond, the demand for farm products will rise. Land which has been retired can be put back into production in better shape than it was in before. The addition of more good land should add still more to efficiency and make it possible to further cut the cost of production and create even larger demand, along with that entailed in the total population growth. Looked at in this way, it would appear that a great deal of promise lies ahead for agriculture, and that for the short range as well as the long, the solution is closely tied in with the more widespread use of conservation knowledge.

I should point out here that the watershed program itself already has offered in recent years one of the greatest incentives to enhancing farm efficiency through conservation. Since the pilot watershed project was initiated in 1953, there has been in my county where it is located a 500 per cent increase in the installation of terraces, waterways and other related measures through the Lancaster County Soil Conservation District, in which at my home, Far Ridge Farm, I am a cooperator.

So much for agriculture, and the improving prospects for the proportionately fewer farmers over the long haul.

The impact of the agricultural revolution is equally great in the mushrooming cities and suburbs where live the rapidly increasing numbers of people who must make a livelihood there instead of on the land.

They too, which I am sure means many of you too, have a tremendous stake in a broadened conservation program if the elements of wholesome living and family enjoyment long associated with rural life are not to disappear from the American way.

Throughout America, the cities and urban areas are undergoing sensational growth, and its end is not in sight. Assuming a population increase of 63.3 million people in the next twenty years, the Census Bureau figures that 46.5 million of these will live in or near cities.

What will these people do with their leisure time, of which if forecasts are correct they will have more and more on their hands as the years pass? They won't spend all of it, surely, in bowling alley joints, or before the color TV sets, or at the public libraries, without surrendering man's precious birthright of communing with the out-of-doors.

Nor will the national parks and forests, precious as they are, offer more than a partial answer to the recreation problems of this tremendous new city population. As the population grows, these beauty spots will become more congested. Traffic on the highways will get worse before it gets better. Even for those who will have the time for the long journey to the big recreation areas remote from most of the population centers, the effort and the risk will make the venture less attractive.

Inevitably, as I see it, we are faced with the need for dynamic, forward-thinking, in developing what I shall call "family-size recreation" spots—places for hunting, and fishing, boating, swimming, tramping, and loafing under the sun—widely and generously dispersed throughout the countryside, accessible for the afternoon or the weekends, and in sufficient numbers so that a man and his boy, his wife and their daughter, can find some fun, solitude, and fresh air.

If we neglect this imminent need, we will be denying for millions of future Americans an inalienable built-in right to the pursuit of happiness which is built into the human spirit.

Happily there are opportunities today for the imaginative and the creative to do something about this vital aspect of the nation's future well-being.

In the Lincoln area we are doing something about it. In connection with the watershed program for the Salt-Wahoo basin, we have enlisted the cooperation of the State Game, Fish and Parks Commission, the National Park Service, and the U. S. Fish and Wildlife Service, in planning a series of lakes where recreational benefits will accrue in addition to flood prevention to be provided by the Army Engineers. We are thinking in terms of lakes with public access, for fishing and boating, and of public hunting grounds, all within a half-hour's drive of our city of 125,000. These will be in addition to some 150 smaller conservation pools behind the structures being installed through the Department of Agriculture's watershed program. Already on those of the latter type which have been completed, wildfowl can be noted in numbers and in varieties not seen in this area within recent memory. These new lakes and pools will last longer, in a more attractive condition, because they will be protected by a complete watershed program of conservation on the land.

For the attainment of similar objectives on a widely dispersed national scale, the broadening of the National Watershed Act through the amendments now in Congress offers a splendid opportunity. Sportsmen, wildlife enthusiasts, and outdoorsmen in general, who I have noted are often good at raising the roof against something—usually despoliation of nature—have an issue here on which they can raise their voices on a positive pitch. They should note that this legislation would permit federal assistance in watershed conservation programs which include recreation and fish and wildlife habitat improvement among their benefits. They should note, too, that many of the states have funds which can contribute to this kind of improvement.

For myself, I don't particularly care what agency of government does what job. It is important, however, that frustrating and wasteful competition among public agencies be avoided or minimized by giving all of them reasonably comparable ground rules and letting the people of the various areas choose the aims, the methods and the agencies best suited to the requirements of the area. More important is the necessity for recognizing, clear across the board of public and private action, the integral and essential relationships of soil and water conservation on the land, flood prevention, enhancement of municipal and agricultural water supply, pollution abatement, and recreational development.

These are all like Love and Marriage. You can't have—or at least you can't *afford* to have—one without the other.

WORLD AFFAIRS AND OUR NATURAL RESOURCES

GOVE HAMBIDGE

North American Regional Representative, Food and Agricultural Representative of the United Nations, Washington, D. C.

The topic assigned me is world affairs. It is a nice large subject—very much like having a bear by the tail. The question is where is he going to take you?

The discussions this morning have covered wide fields—land use, industry and business, national welfare, national security. I like this way of beginning a conference. What you are doing this morning is to set your special interest, wildlife management, in a framework that shows its relationship to other basic and important things.

The discussions this morning have been concerned with national questions. As a representative of the Food and Agriculture Organization of the United Nations I am going to take you into the international field. I shall not hesitate to plunge into a very broad-scale discussion, because in my experience people who are seriously concerned with wildlife management and conservation are likely to be people with a broad humanitarian outlook. That is natural, I suppose. No one can be closely associated with fields and forests, the seas and rivers and lakes and the sky, without having the kind of vision that takes in large horizons and looks outward on the universe.

Essentially your concern is the sound management of certain of the earth's most fundamental living or biological resources in order that man may enjoy them for a period as close to perpetuity as we mortals can envision.

What I shall be talking about this morning is sound management not only of these resources but of the whole earthly setting of which they are a part, and of which man himself is a part.

If you will drop the word *wild* from the name of your institute for the next fifteen or twenty minutes and think of it as something even bigger, the *Life Management Institute,* we shall be talking the same language.

World affairs are in an interesting and precarious state.

What is the first thing you think of when you hear that phrase, *world affairs?* The first thing I think of is the overwhelming fact of life today—the new possibility of total or almost total destruction of the living resources of this planet through international conflict with atomic and nuclear weapons. If such a conflict should occur, we might have some wild life left in places, but there might be very little else—probably no civilized life as we know it.

I am sure you will agree with me that the *first* preoccupation of men and nations today is and must be the effort to eliminate the possibility of this kind of conflict. I am optimistic enough to believe we can do it; but as the Secretary of State pointed out last week, it would be reckless to assume that, because we know modern weapons in a major war would destroy a large part of the human race, this knowledge in itself will forever prevent the occurrence of war.

Few of us can participate directly in the kind of negotiation required to provide adequate insurance against conflict with these terrible weapons.

A great many of us, however, are involved, directly or indirectly—and I believe many more of us will be in the future—in another kind of effort just as important for creating an environment favorable to lasting peace. This is the effort to remedy conditions that have always been among the principal causes of armed conflict.

I speak of hunger, poverty, ignorance, disease, frustration, which in too large measure are the lot of too large a part of the earth's people.

These are conditions that breed discontent and unrest, and lead to rebellion and revolution; and because violence in these forms could be the spark that sets off a world conflict, we must in this atomic age do everything we can to forestall it.

My remarks this morning are concerned with the effort to change these dangerous conditions by peaceful methods before men resort to violent ones.

I speak of what we rather awkwardly call the economic development of underdeveloped countries, through what is awkwardly called technical assistance, or technical cooperation.

Next to direct negotiations concerned with armament control, I regard this business of widespread economic development as the most weighty and important business in world affairs today. This business is essential to economic health; and as long as there are immense sick spots and sore spots in the world, as there are now, much of the world cannot have the economic strength and material well-being, and a large share of the world's people cannot have the freedom and opportunity, which are the foundation stones of peace.

Now I want to take you to a high place and give you a quick bird's-eye view of this movement for economic progress which has suddenly become worldwide in the past few years.

It started at the end of the war as a large-scale drive for relief, rehabilitation, reconstruction—a drive based on the necessity for quick repair of the damage caused by the most destructive of wars if the world was to escape a long period of despair.

But the relief and rehabilitation aspects soon merged into something more long-range and forward-looking when the United States Government called the Conference on Food and Agriculture at Hot Springs, Virginia, in 1943. That conference resulted in the setting up a couple of years later of the Food and Agriculture Organization, FAO, the first of the new United Nations agencies, born even before the United Nations organization itself.

Thus, significantly, I think, the first of the new international agencies was concerned with nutrition and agriculture and forestry and fisheries; with man's fundamental needs, food, clothing, shelter; with better use and management of the living resources that provide these things; with the innate longing of most human beings for a life less heavily burdened with hardship.

Significantly, too, the first of the new international organizations was essentially scientific and technical rather than political in nature.

Significantly, it was based on the progress made by science in opening up great new possibilities for improving the production and processing and handling and distribution of the things needed for higher living standards and enhanced welfare.

Significantly, it took the form of a cooperative international effort to make the necessary knowledge and equipment so widely available that a large part of mankind could achieve greater abundance than man had dared to think possible before. Men were to cast their knowledge upon the waters of good will in the belief that it would return to them many-fold.

FAO was one of the catalytic agents that helped to stimulate this drive for economic development and get it off to a vigorous start. But the movement soon grew far beyond FAO. Other agencies came into the picture, notably the International Bank for Reconstruction and Development, the World Health Organization, UNESCO. They are international; FAO, for instance, is a cooperative of 72 governments, and its staff and its funds come from the entire membership, though the U. S. contributes the largest single share.

But the effort very soon spread beyond these international agencies. In fact, the bilateral or so-called Point 4 program of the U. S. Government and the essentially bilateral program of the British Commonwealth countries in the Colombo Plan soon far exceeded the operations of the strictly international agencies, both financially and in the numbers of professional workers involved.

In addition, there has been a great enlargement of technical assistance work on the part of private foundations, notably the Ford Foundation and the Rockefeller Foundation, but several others also; and religious missionary groups have enlarged their work overseas in rural development, in medicine, in education; and colleges and universities have taken an increasingly dynamic part in the whole movement, to such an extent that I think every land-grant college in the United States now has members of its staff working in one or more countries abroad, usually on contract with the federal government.

So you now have a tremendous ferment of activity.

Toynbee once said that our age may go down in history not as the age of destruction but as the age in which man dared for the first time to think that every human being can share the benefits of modern civilization.

In a nutshell, I suppose, that is the meaning of this drive to widen the horizons of opportunity which has become so dominant a part of the life of our times.

Practically all of the work of FAO has at least an indirect conservation aspect in the sense that it is profoundly concerned with better use and management of the renewable resources of land and sea. A fair amount of the work directly involves conservation.

Let me give you two or three examples, first commenting that while most projects and programs are carried out within individual countries, governments are also using FAO as a means of organizing cooperative regional efforts to deal with problems common to a number of neighboring countries.

In the Mediterranean area and the Near East, for instance, there has been serious deterioration of vast areas of grassland through overgrazing and haphazard management. Considerable parts of this great semi-arid region are peopled by wandering Bedouins perpetually on the move seeking fresh grass for their flocks and herds.

To bring about better management of these range lands is a difficult task, since it involves changing ancient ways of doing things, deeply embedded in law and custom. But changes there must be because the very life of the region depends on water; and the great guardian of water is vegetation; and extensive, serious damage to the vegetative cover is like condemning the thirsty land and people to slow death.

A number of these countries are now combining through FAO on a promising program of research and experiment designed to determine what grasses and other forage plants are best adapted to the needs of the area and what management practices are required to maintain a favorable balance of plants and animals and people.

In the Far East the International Rice Commission, an FAO organization, has brought many countries together in an effective program for breeding better rice and making many other improvements in rice production. Rice is the staple food in much of this region. If, through the use of better varieties or otherwise, the same amount can be grown on four acres that previously required five, you have an extra acre that might be put into legumes or grasses or other plants, thereby diversifying agriculture and protecting soil fertility.

In the Far East, the Near East, and Latin America much skill and effort is now focussed on improving livestock production—in particular, combatting widespread diseases such as rinderpest through new methods, cooperatively applied. I need hardly emphasize to this group that better soil management and expanded livestock production often go hand in hand.

In forestry the principal effort is to bring about a wider realization of what sound forest management is and to help governments institute the laws and establish the organizations required to put it into practice. Essentially this means going over much the same road that this country traveled in the long struggle to put forestry on a sound basis.

The FAO regional forestry commissions are all working on one or more aspects of this big problem. In the Near East, one of the main concerns is to bring back some of the forest destroyed long ago and urgently needed for soil and water protection. In parts of Latin America, a pressing problem is to make far better use of large forest resources now either scarcely utilized or, at the opposite extreme, wastefully exploited without regard to the requirements of sustained yield.

The potential contribution of fisheries to the world's food supply is a good deal larger than the actual contribution today.

One need is to prevent a great deal of waste in the handling, processing, and transportation of a very perishable product. Another is to increase the efficiency of millions of fisherfolk who are so desperately poor that they have neither the boats nor the gear to go far enough offshore for a good catch.

One of the most interesting developments is the rapid expansion of inland fish culture in ponds, streams, brackish waters, flooded rice fields. By stocking his rice paddy with fish, the peasant farmer kills three birds with one stone. He provides a natural fertilizer that increases his rice crop; he gets a very sizable supply of good protein food from the same land that produces the rice; and he effectively reduces the mosquito population.

As for the work of FAO in improving nutrition, it is a vital aspect of the conservation of human life itself. Malnutrition, inefficiency, disease, and frustration are a vicious circle. Our concern is to break it at the point where nutrition is involved.

Consider rice processing, for instance. Millions of human beings live almost exclusively on a rice diet. Yet a good deal of the rice they eat is so highly milled and wrongly handled that it loses disastrously in nutritive value. FAO is very much concerned with getting better milling and handling practices widely used so that vital minerals and vitamins can go into human stomachs instead of being thrown away.

* * *

These sketchy random examples are not intended to give an adequate idea of our work.

I have not even mentioned, for example, the project we are now planning to carry out—an international survey of the world's potential production of food—the most comprehensive ever undertaken—to see how it matches prospective population growth. Nor have I mentioned the possible use of atomic energy in agricultural production and related fields—a possibility fraught with dangers as well as benefits.

You can read about these things elsewhere. Here, I am more concerned to leave you with the conviction that the work of FAO and its sister agencies, national and international, public and private, adds up to one of the most significant of all man's ventures into new realms of human well-being—a venture that must succeed if there is to be any world for our children and grandchildren to inherit.

I am concerned, too, to show that the heart of this work is better management of the earth's great living resources; and because this is so, it is very much up your alley as experts in—I repeat—*Life Management.*

I would suggest, in fact, that you ought to scrutinize the work of FAO and similar agencies with special care to make sure that they pay enough heed to conservation for their own good. Far better than most people, you realize how easy it is to neglect that aspect in the pressing, persistent drive for greater production.

DISCUSSION

VICE CHAIRMAN HERBERT: Is there any discussion?

It would seem fitting to have some questions for the record. Has anyone any questions to ask of the previous speakers? Well, we should have one question and I want to put that into the record.

The papers presented this morning all stressed the importance of using the basic resources, the land and water, so that they will supply the maximum of goods and services for man's well-being. The question is: "Can a yardstick be developed to measure more accurately the importance of the several uses of these resources? Some conservationists believe that the yardstick now in use is distorted. I merely mention this for the record.

MR. HOWARD ZAHNISER: I was especially interested in Mr. Hambidge's discussion of frustration and I wonder if he would like to elaborate a little more in connection with that?

MR. HAMBIDGE: I don't think that anything more needs to be said in connection with that. I think that frustration takes many forms. There are the forms of mental stress and so on.

I would like to say that I have a book here. It is called "The Story of F.A.O." It is a good book and commercially published. It has a lot of good pictures and it costs $6.50. I have a copy of the book here which I am going to give to Dr. Gabrielson.

VICE CHAIRMAN HERBERT: Do any of the other speakers have any comments they would like to make. If not, I will turn the meeting back to the Chairman.

CHAIRMAN WILLHAM: I would like to thank all of the speakers for their contributions this morning. Let me say that it has been hard for me as a former college professor to refrain from making some comments between each of the papers here. They have all been interesting and worth while. There are a lot of questions that I know have come up in your mind and I hope that even though we have been a little rushed for time that you have gotten something out of all of these papers. I know that we owe a lot to Mr. Hambidge and we certainly appreciate all that he has done. I have done a bit of preparing for this meeting and I know that I had some questions that I would like to have asked.

I would like to close with a statement of congratulation to you people for what you are doing in your various organizations here to keep our country a more livable country so that we can have proper conservation management.

Again thanks so much for your attention this morning.

GENERAL SESSIONS

Tuesday Afternoon—March 6

Chairman: William J. McGlothlin
Associate Director for Regional Programs, Southern Regional Education Board, Atlanta, Georgia

Vice-Chairman: Hiden T. Cox
Executive Director, American Institute of Biological Sciences, Washington, D. C.

HOW TO GET COORDINATION IN CONSERVATION

INTRODUCTORY REMARKS

William J. McGlothlin

The topic that we have assigned to us for the afternoon seems to me to be an extremely interesting one. As I looked at the title it occurred to me that there were four assumptions on which such a session as this must be based.

The first assumption is that coordination is desirable. If that is not the case then there would be no point in having a topic like this.

The second assumption, in the event that the first assumption is correct, is that we do not have it—that, however desirable coordination is, we do not have it.

The third assumption is (and here I begin to get on somewhat shaky ground) is that we can get it. I don't think that we should spend our time on anything which we feel is impossible of attainment.

The fourth assumption, and that is the reason we are here this afternoon, is how to get coordination in conservation.

Therefore, you might keep these four assumptions in mind as these papers are presented to you—(1) coordination is desirable; (2) we don't have it; (3) we can get it; (4) this session will help us to see how we might be able to attain it.

THE PLACE OF EDUCATION AND RESEARCH IN THE FORMULATION OF A CONSERVATION POLICY

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There is no area of endeavor where the need for pulling together, coordination of effort and enlightenment is more essential than in the use and care of natural resources. The need certainly is as great today as it was in 1908 when Teddy Roosevelt said that conservation was "the chief material question that confronts us second only to the great fundamental question of morality." In fact, the need today is greater than in 1908 since evidence of our adverse actions are not so much a conjecture, but a measurable reality. The problem is now more complex and difficult of solution since the societies of the North American countries are themselves more complex and dynamic. Yet, in spite of need, most of these countries have not formulated a policy for conservation which is getting the job done. It is not because they haven't wanted to—goodness knows, they have tried. The question might be asked, "Why have they failed to bring the management of their resources to higher levels?" It is hoped that in this paper on education and research, and in the papers of other members of this panel, some of the answers may be found.

I do not wish to imply that we have done nothing in conservation. However, I believe that our efforts have been too sporadic and have lacked the degree of coordination necessary to be effective. Too often, measures containing conservation implications are designed for the purpose of correcting other economic, social and political problems with the result that conservation accomplishments are more accidental than calculated. It is time to develop criteria and objectives for the formulation of a more specific and calculated conservation policy. Once developed, by applying constantly improving tools and techniques, this policy can be executed with more effectiveness, and with greater coordination than those of the past. We can be encouraged by recent efforts in this direction by many levels of government, by many agencies and industry. Yet we cannot become complacent since much more needs doing, particularly in fact-finding and education, before adequate solutions can be found.

The term *conservation* embodies an idea that is new. It was first used in the latter part of the last century and was associated with a crusade designed to awaken the American public to the dangers of resource depletion. The crusade, in this respect, has been successful, yet results in terms of actual resource conservation have been dis-

[1]In the absence of the author this paper was read by Dr. Kenneth E. Hungerford.

appointing. The reason for our failure, in spite of the awakening, is because specific methods, techniques and procedures for attaining resource conservation have not been studied sufficiently to formulate a workable plan. Thus, guides for specific and coordinated action have been lacking. The word conservation, since it was associated with something that was nebulous, was of little help in conveying a sufficiently specific idea for the development of objective guides. The use of the term stirred us up emotionally but emotions based on insufficient facts can run wild.

As a result, the term conservation now means different things to different individuals and generations. Included in the concept are such ideas as idealism and moral obligations to future generations. As admirable and necessary as these are, they only set the framework within which the real scientific work must function to get the job done. We need less emotionalism and idealism and more down-to-earth scientific enlightenment concerning factors which influence conservation of individual resources. Thus our objective can be attained only through more research which will supply the facts upon which an objective educational plan can be based.

Unfortunately, the lack of facts and enlightenment is acting as a barrier for improvement. I say this because, without a definitive concept, everyone does what he wants to concerning conservation. Every group proposes policies which will meet the needs of their own specific interest. These policies will naturally conflict with the policies of other groups. Unarmed with adequate information and being ignorant of the facts, biases are used to sway emotions which create more biases, and so the cycle goes. The result is conjecture, name calling, propaganda, and a spreading apart of opposing interests. With these conditions existing, how can we expect to resolve conflicts, a resolution of which is necessary before constructive action is possible?

It should be plain that more facts and more enlightenment are necessary before a workable conservation policy can be formulated, implemented, and executed. The Malthusian pessimists, basing their judgment on increasing populations and waning resources, see nothing but darkness ahead. With enlightenment, they will not have the appeal they now have. Likewise, those people who are overly optimistic, because of the known rewards of technology, will realize that technology may not be helpful if soil depletion goes too far. Further, all will realize that technology has done little to preserve those natural elements of environment wanted and enjoyed by all. There is a middle ground, based upon fact and realism, which we will come to understand.

Don't think I am so naive as to believe that we will not have conflicts even with enlightenment. Policy decisions will be influenced by conflicting groups in the future as they are now. I am convinced that many seemingly large differences become smaller as the facts become known. Knowledge of the facts, and a willingness to accept them, will help conflicting interests understand each other.

Our conservation objective should encourage private enterprise in the development of the industrial means whereby the resistances of nature can be most efficiently broken down in order to satisfy our material wants. On the other hand, it should be one which will guarantee ways and means of preserving to the maximum those non-material, natural values which are so essential for our well being and enjoyment. The attainment of this objective will not be easy since resources are relative to man, his wants, abilities and objectives, which are constantly changing. Demand for a certain element of Nature's supply may be intense for a time. With changing technology wants or objectives, the demand may wane, and another element may take its place. The conservation concept should embody and recognize a dynamic situation wherein man and resources are interrelated and that the status quo is impossible. Enlightenment, resulting from fact-finding and education, will help identify, isolate, and classify the forces involved in the above mentioned concept of conservation. A study of the forces and implementing tools constitutes the subject matter of the educational plan. Let us turn to a consideration of a few of these.

I will consider first the influence of economic forces on conservation. It is necessary to know the influence of these forces before past actions can be explained, future actions predicted, and corrective measures formulated. Understanding the influences of economic forces will prevent actions of society which work adversely to conservation under the system of private enterprise. Economic forces help explain the actions of private owners in the past, for example, the former "cut-out and get-out" policy of the lumber industry. Understanding these forces also will help us predict with greater exactness the future impact of present prepared plans on resources and conservation; for example, why plans for present and future action of the lumber industry assure conservation of the forests. The present individuals of the lumber industry are no more altruistic than their predecessors; however, economic calculations prove that sustained yield is good business under the influence of current economic forces. Knowing the influences of economic forces will help decide what market forms are best for conservation, what owner reaction will be, and through this reaction what will be the influence on conservation of such economic forces as: changing interest rates, uncertainties caused by economic instability, the influence of credit, taxation changes and forms, cost price changes, price supports and many more. It will be possible, further, to determine whether economic instability is caused by resource depletion, or whether depletion is a result of economic instability.

Conservation is attained by investing money today, such as in tree planting, the cost of which can be recaptured in the future, or by deferring use. Conservation costs will not be incurred or use deferred unless economic calculations show this action to be wise. Actions are influenced adversely by uncertainties, uncertain taxation levels, unstable price structures, adverse public pressures, and many others. Public response to these matters can either instill confidence or destroy it. Because we do not understand economics, too often we turn to other measures to get results, such as regulation, subsidies, and public ownership. Knowing the above facts will help pin-point the problems so appropriate and workable means can be found for corrective measures.

I do not wish to imply that understanding the economic scheme will provide all the answers for solving conservation problems. I do imply that the above mentioned economic forces and conditions can work favorably or unfavorably for conservation. By knowing the exact influence of each, much can be done through public action, to cause these forces to react favorably. Thus, I sincerely believe that with enlightenment much can be done to make the economic system more compatible with conservation.

Imperfections are present in the economic scheme, from the standpoint of assuring conservation of all resources under all conditions. This is particularly true where in harvesting the commercial values economic forces dictate practices which are not compatible with the fullest realization of public benefits such as water, recreation and wildlife. Let us consider then what could be done in those cases, after economic possibilities had been exhausted and desirable results not attained.

I first wish to mention the principle of compensation by using an illustration. Suppose, to protect the public values during a timber harvest, the owner has to incur an added cost of $5.00 per acre or sacrifice an equivalent income. Can we expect the owner to absorb these costs when the resulting benefits are entirely public? No, I don't believe we can, nor do I believe that individual owners are so altruistic that they will do so on their own. If the principle of compensation is practiced, the public would pay directly for this added cost, and justly so because they are the recipients of the benefits. Regulation may be used along with compensation to assure results.

On the other hand, regulation which increases costs not compensated for can only result in higher wood prices, lower stumpage prices, or possibly the elimination of private enterprise. None of these may be desirable for the attainment of conservation. Fish and Game Departments might well consider the principle of compensation in the expenditure of Pittman-Robertson funds for habitat improvement.

Restriction of use is preferable to the principle of compensation in those situations where public values are high in relation to the commercial values, and where costs and benefits are difficult to allocate. In these cases, commercial uses are restricted to those which, during extraction, do not influence excessively the public values adversely.

Public ownership is preferable to compensation or restriction of use under those conditions where there is a high degree of non-compatibility between many uses, where single use of non-commercial nature is best, where allocation of costs and benefit is impossible, and where special and costly methods of management are necessary to protect all values adequately. Beyond this, public ownership of certain resources may be desirable where economic forces in the long run prevent conservation practices under private ownership even if commercial values are high.

A tool that is often effective in bringing about conservation under certain situations is the subsidy. Subsidies are useful in encouraging conservation when economic forces are temporarily working unfavorably for conservation. They are also useful where conservation costs cannot be recaptured for several years, and the owner cannot get sufficient long-term credit to get the job done. Subsidies should not be used under those conditions where, through education, better conservation practices are brought about and through such practices sufficient returns accrue to make such expenditures profitable for the individual.

Most of the above mentioned methods are being used to varying degrees at present; however, we need a better understanding of the principles and practices and a greater coordination in the use of them and among the many agencies administering the programs.

Now I wish to discuss the merits of education more specifically and to consider the "who" of education. Education offers one of the most effective tools at our disposal; however, we should recognize that education is not a "pink pill" that will cure all ills. That education has its place is axiomatic, yet it also has its limitations. Too often, possible results of education are overestimated by conservationists. As explained above, resource owners do not always respond under the influence of economic forces as we think they should. The easiest course is to blame such on the ignorance of the owners. Education, therefore, appears to be the logical and simple solution. However, if economic and other factors stand in the way, and prevent owners from carrying out best practices, results of education alone will be small.

Education costs money and is, in effect, a subsidy. Thus, education as a tool of conservation should be used wisely, honestly, and only where appropriate. Malicious and non-factual propaganda to promote selfish interest, under the guise of education, cannot be condoned. Reactions to such frequently undermine honest and sincere efforts in education.

In democratic countries, sound conservation policies are dependent upon the intelligence of the adult voter. Thus education material must be factual, unbiased, comprehensive, and must be presented in an honest, sincere and palatable fashion so the voter can use discretion in the exercise of his responsibility.

Biases that are a carry-over from the past must first be removed, before objectivity can be attained. This is not easy since these biases are deeply rooted. To illustrate this point, I will refer to my freshman class in forestry at the University of Idaho. In the first lecture I asked the students if they thought cutting of the forest was bad for conservation. A surprisingly large number said "yes." They must have read or had been told about the "lumber baron," "land grabbers," "capitalist," "ghost towns," etc. True, these charges may be justified but such education is not the objective, scientific forward-looking type that will remove emotions and permit the exercise of reason. Public education also must be comprehensive, particularly when dealing with multiple resources on single areas. One of the multiple aspects should not receive a disproportionate amount of attention at the expense of the others. The true ecological interrelationship among all resources should be stressed. The idea of maximizing total benefits is more important than stressing one at the expense of the others, a practice which might result in benefits less than maximum.

Much more attention should be given the subject of conservation in the training of young people. Conservation should be a subject in civics courses, yet this is not often the case; where it is, misinformation is too often given. Conservation is taught as a vague idealistic concept the youngster feels he must have before he can become a good citizen. He is not given the real information necessary for understanding what conservation is or what his responsibilities are. I believe the teachers do not appreciate the subject themselves. Therefore, why isn't the subject of conservation necessary for all teachers graduating from teachers' colleges and universities? If it were, and if taught by only those who are qualified, we would not have, in time, situations portrayed in the following example. I was driving with my family on the west coast of the United States, when we arrived at a forest area which had been recently clear-cut and burned. From a public relations standpoint the area looked bad because there was still much large timber lying around and there were no young trees. At this point, my 10-year old daughter said, "There is a good example of poor conservation." I asked her where she got the idea that such was poor and she said, "In school they told us that cutting of all trees at one time was bad." In this case, clear-cutting in blocks, followed by burning of slash is an approved practice which is generally compatible with the use of other resources. At the same time youngsters were being taught concerning the bad effects of fire. Thus, when the industry was carrying out an accepted practice with the use of fire, they were receiving public criticisms. Can we not all agree that such education is not best for conservation? Thus it is extremely important in young adult education to stick to the facts and to remove emotionalism and untruths. To do otherwise is worse than doing nothing at all.

In North American countries, conservation only recently has become economically possible. Thus, conservation techniques are not instilled in the young as is the case in European countries through traditions and customs. Education is the first step in developing conservation traditions and customs which can be passed on to the future generation.

When considering education of the resource owners, we cannot always assume that not practicing conservation is due to their ignorance. In many cases, they may be applying best knowledge; however, under the impact of current economic forces better conservation practices are impossible. In these cases, education is of little value and we must consider measures previously discussed in this paper.

In many situations, however, best knowledge is not being applied and resource depletion results. Here education is the answer, and is probably the cheapest tool that can be used to get results. I say this because often applying best knowledge will not only bring about better conservation practices but, over time, will bring greater returns to the individual.

In the past, too much of our educational effort for owners has been along engineering and technical lines to correct depletion which has already gone too far. I am referring to instruction in methods of stopping erosion, pollution abatement, and the like. Certainly such education is needed, however, it is not necessarily the most important. The most important and probably more difficult task is education which is necessary to detect early signs of resource depletion. If early detection becomes a reality, costly engineering and technical methods may later be unnecessary.

It is a highly scientific job to detect early signs of depletion; for example, in soil. Also, to detect early signs of ecological retrogression in forests and ranges requires technical knowledge beyond the grasp of the average owner at present. The lack of such detection can partly explain undesirable changes in forest composition here in the south, and range grass depletion in the western states even though the soil has not been depleted. One reason for our failure in this respect is that research has not yet provided simple and practical techniques which can be used by the scientist or by the resource owner without excessive costs.

Adequate understanding of the ideas mentioned in this paper, I believe, are necessary for an objective non-complacent approach to our conservation problem. I mention this because even though studies have shown that soil fertility has been reduced materially in many agricultural areas, production has actually increased because of technological improvements. This cannot go on forever or we may find ourselves without the basic resource—soil. Because income levels are higher after soil depletion occurs, we should not be blinded to the possible long-term adverse influences of present practices. Economics alone, in this case, can lead us astray. Thus we must call on a team of physical, biological, and social scientists to determine the true situation. It is necessary to have all scientists, along with enlightened resource owners and the public, working together under a coordinated and specific plan to solve one of our most complex problems—resource conservation.

CONSERVATION LEGISLATION AND POLICIES

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An old Kansas friend and I went duck hunting one day. The duck flight was poor but we happened upon a set fishing line that had a tired two-pound bass hooked on it. So we did not go home entirely empty-handed. That incident, I fear, just about illustrates the extent of the bag you can expect this year in the way of national conservation legislation. There will be some gain, but it will mostly be the indirect result of legislation enacted for another purpose.

The proposed soil bank, or at least the conservation reserve part of it—if passed in a practical form—could represent a real advance in better land management. That is where the incidental benefit comes in. As the Wisconsin Conservation Commission said in its 1955 statement of policy:

''Adequate game and fish habitat, with attendant game and fish populations, are by-products of well-managed land.'' How well the soil bank program will work out cannot now be calculated. But to the extent that it puts a conserving cover on the land and provides a cleaner flow of water in our streams it means *that much more* of a favorable environment in which wildlife may live and reproduce.

Of course, it is going around Robin Hood's barn to accomplish what could be done better and more permanently by a *far-sighted and unified conservation policy*. But that seems to be the way we do things in dealing with our renewable natural resources.

A large number of bills dealing with water, inspired by both flood and drought, have been introduced in Congress. Many of them will be passed since, this being an election year, Congress wants to do all it can for the home folks. But they represent the usual piecemeal type of legislation and conform to no orderly policy. One of the most helpful among them is the measure to broaden the provisions of the Watershed Protection and Flood Prevention—or small watershed—Act. When this act was passed its usefulness was limited by crippling restrictions slipped into it by Senate friends of the Army Engineers and Reclamation Service. Watershed projects were required to be primarily of an agricultural nature; there were no provisions enabling them to be developed for such purposes as increasing water yield, providing municipal and industrial water supplies and improving recreational resources. So the act fell far short of the multi-purpose aims of those who sponsored it and failed to get the broad local support necessary for its success.

Most of these hampering restrictions have been removed by the bills now before Congress. They provide also for 50-year loans to local organizations to help finance their share of the cost. If these amendments are passed the result could be a considerable impetus to watershed development and its multi-purpose benefits.

The one major proposal—the report on Water Resources Policy by the President's Inter-Cabinet Advisory Committee—has aroused no enthusiasm so far. It might be described as bringing down some feathers but no ducks. The report seems intended as a compromise between the recommendations of the Truman Presidential Commission on Water Resources Policy, headed by Morris L. Cooke, and the recent Hoover Commission's task force report on Water Resources and Power. It promises to gather dust with these and other studies of water problems and needs, now growing to almost library size. Some of the defects of this latest proposed water policy might be summarized thus:

It does not recognize that a successful water policy must be geared in with a comprehensive natural resources policy. Water is only a part of the inseparable complex of land, water, forests and the living creatures that have their habitat in and upon them.

The federal devices it sets up for coordination are themselves divided and administratively complicated.

The means it provides for federal, state and local cooperation are vague and unwieldy.

Upstream measures for land and water conservation and watershed development and downstream engineering works for flood control and channel improvement are not correlated as they must be if a complete program of water management is to be achieved.

I have touched briefly on what is going on because I think it points up two things:

1. We are still proceeding on the same old hit-and-miss basis, with action dictated largely by emergencies and political considerations rather than by foresighted planning and policy.

2. The increasing concern about water, now becoming the most critically urgent resource problem, will sooner or later bring some sort of policy, wise or ill-considered as may be.

It is to the interest of all of us to realize this fact and to do all we can to see that it is a policy for the conservation, consistent development and sustained use of our renewable natural resources in their entirety. Is a sound coordinated policy of this kind possible? I believe that it is. Realizing that I am presenting a wide open target, I'll offer the elements of one that has been tested by the thinking of a number of people.

It should start with an *act of Congress establishing a comprehensive* *policy* in respect to the lands, waters, forests and related renewable natural resources of the United States. This act should specifically state: That, since these resources are inextricably bound up with one another in the economy of nature, their needs and problems require a unified approach; that the policy shall be the joint responsibility of the Federal Government, the states and their local sub-divisions of government; and that it is to be effectuated through cooperation of the Federal Government, the states and their various sub-divisions, the owners and users of these natural resources and private groups and organizations serving as a medium for public participation.

Such a declaration by Congress must precede any effective resource program. Until you get it I do not see how coordination among the diverse Federal agencies is possible. Their activities are rooted in hundreds of previous legislative acts and some over-ruling national policy is necessary to bring them into order.

But a policy is not self-operative. A Commission on Renewable Natural Resources should be established to study and recommend means of carrying it out. All of us know the hazards that go with a Commission. So I would require that it be composed of one member each from the Departments of Agriculture, Interior and the Army, three representing the states, three the local sub-divisions of government and three representing the public at large. And I would require further that all of them should be qualified by expert knowledge of or practical experience with the problems and management of the lands, waters, forests and related renewable resources of the nation. This should insure a Commission that is equipped for the task and should remove that apparently persistent curse of Commissions—the desire to exploit some theory of government rather than get the job done.

Now I have some ideas of what the Commission should do and should recommend. It should study the facilities—Federal, state, local and public—with which to meet the requirements of this national policy and formulate a practicable program by which it can be accomplished. This should be a positive program designed not simply to meet resource troubles but to develop the multiple opportunities they offer for increasing public benefits. Here is where a good start could be made on the needed coordination also. The Commission should define the respective spheres of administration and responsibility among the federal, state and local governments and assign the services and functions the various Federal agencies shall perform. Its recommendations should include some for state action as well as Federal. Unless you get effective state programs no national policy can succeed. I think one of its recommendations might well be that every state should work out a complete program to fit its resource needs as a requisite for Federal cooperation. Some states—Ohio and Wisconsin, to mention a couple—are already setting good examples. These state programs can then be synchronized with major basin plans. Indeed, they should be a necessary preliminary to such large-scale improvements. We would avoid such one-horsed propositions as the present so-called Missouri River Basin Plan if they were.

Finally, I think the Commission should recommend that *a National Board of Review* be established to pass upon the various projects and programs that will be instituted under this policy. It should be concerned with their practicability, their accord with the basic policy and the priority they rate. The Board would report its findings and recommendations to the President for inclusion in the budget and to Congress for approval and appropriations.

Such a Board would need to be a very responsible body. It should be manned, God forbid, not by economists or engineers or politicians but by men of demonstrated ability and experience in this broad and complex field. We have enough of them, I'm sure, to make up a competent five or seven-man Board.

This plan is doubtless full of holes. If so, you can expose and, I hope, correct them. But years of active observation have given me two convictions. None of us can hope to achieve what we wish for our particular interest, whether it be soil, water, forests or fish and wildlife, except it be in company with the others. They are all parts one of another. The other conviction is that a definite national policy must be declared by Congress if these resources are to receive the attention due them. That policy should aim at more than just meeting resource troubles. It should look also to the opportunities—such as the opportunities for multiple uses and benefits now going neglected in all but a dozen or so of our thousands of watersheds. We've been fighting the battle for our natural resources along Korean War lines long enough.

DISCUSSION

CHAIRMAN McGLOTHLIN: Are there any comments on this paper?

MR. SELKE [Minnesota]: I would like to commend the writer on an excellent paper.

MR. BOYD [Pennsylvania]: I was disappointed in that it contained no mention of pollution abatement and control. Mr. Taylor is generally such a sound thinker that I am puzzled as to why he should consider it of such minor importance and not worthy of inclusion. I am quite positive that it must have been an oversight. If we are going to have a comprehensive policy and something that is important then I certainly think that water pollution abatement should be taken into consideration.

MR. HIDEN COX [Washington, D. C.]: Speaking as one not in the field, I wonder if someone could enlighten me as to how many years away such a national policy might be.

MR. ZAHNISER [Wilderness Society]: I might be tempted to say that it might be four months away and, if not that, it is more likely to be four years distant. However, this is something that is not introduced with complete newness.

The Natural Resource Council of America, at the time that Mr. Voight was chairman, formulated a proposal much like this. Mr. James Marshall of New York, at the time he was president of the Board of Education there, suggested such a commission.

The political attainability, I think, is related to the elections, and I think that during this session of Congress would be an excellent time to accomplish it. If that is not done, then perhaps it will require introduction in the first Congress of a new administration. However, if we mobilize then I think that in four years we can attain it.

EXECUTIVE DIRECTION IN THE COORDINATION OF CONSERVATION ACTIVITIES

HARRY A. CURTIS

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The general theme of this afternoon's session is "How to Get Coordination in Conservation" and five addresses on appropriate phases of this problem are scheduled. Of these, the first address is on "Training and Research," the second on "Legislation," and the third on "Executive Direction." The sequence is significant, for surely if legislation is to be wise and effective it must be guided by the advice of men who have intimate knowledge of the subject under legislation; and if the advice given is to be sound and reliable it must be based on knowledge derived from controlled research and not on the whims or the unverified assertions of casual observers.

Legislation designed to promote coordination in conservation activities should certainly be based on well-established facts, but if it is to be wise legislation a factual basis alone is not enough. The best that informed legislation can do is to declare objectives and set up a general pattern of procedures and limitations. Perhaps the most desirable component of good legislation is flexibility in its provisions, leaving largely to subsequent administration the task of devising appropriate and effective ways of reaching the declared objectives. And, of course, it scarcely needs to be said that legislation concerning natural resources, including wildlife, scenery, water, land, mineral deposits, can seldom deal wisely with any one of these without reference to others.

In times past and to a lesser extent today, both individuals and organizations devoted to the conservation or restoration of a particular resource have disregarded all other interests. This can lead only to confusion and often results in negation of the very goals sought by the single-minded enthusiasts. It is surely one of the desirable goals of good legislation, both state and Federal, to coordinate the uses of natural resources to the end that the benefits may be maximized and that these benefits be as widely distributed as possible. By and large, both state and Federal legislation looking toward the wise use of natural resources has been overwhelmingly good legislation, although one may easily cite examples in which this has not been so. It is rather surprising that legislation has been as good as it has, considering the terrific pressure from predatory interests to which legislators are always subjected. Sometimes, however, legislation fails and then the public pays a high price for what some folks erroneously call "free enterprise," when what they really mean is freedom from any consideration of the public's interest.

I have begun my address by referring to sound data and to wise legislation, for administration or executive direction of conservation programs must be within the framework of applicable laws. Unless these laws are sound and wise their administration is greatly handicapped. Even under laws that are well-founded, the executive direction of a broad conservation program is not a simple task.

If I am to draw on my own experience in the executive direction of a conservation program, I shall of necessity use cases with which I am familiar through my long association with the TVA. It is not my intention, however, to discuss the TVA in all of its many activities.

As for legislation, I express the opinion that the TVA Act of 1933 was a wise and effective one. I am not here referring to a political philosophy but to a specific piece of congressional legislation that provided the general framework for an organization charged with the responsibility of accomplishing certain objectives desired by the Congress.

Broadly speaking, the TVA Act provides for a Federal agency that, in cooperation with state and other local organizations, would concern itself with the coordinated development of all the natural resources of the Tennessee Valley. The Act gave the TVA Board of Directors wide discretion in devising the means by which the objectives were to be reached. Over the years the TVA has devised programs dealing with the water that falls on the watershed, the forests that cover about half the Valley area, the agricultural lands of the Valley, its mineral resources, fish and wildlife resources, recreational facilities, safeguards to public health and safety, and with various other factors that concern the economic and social welfare of the region. Nothing could be further from the truth than the rather widely-held idea that the TVA is only a venture of the Federal Government in the field of public power.

It will be noted that the problems confronting the TVA Board in giving executive direction to such a broad program of resource development as mentioned above are many and difficult. Of course, the Board does not rely wholly on its own wisdom and mental inventory in dealing with these problems. It has available within the agency the knowledge and experience of professional foresters, agriculturists, engineers, doctors, fish and wildlife experts, chemists, economists, personnel officers, lawyers, and competent advisers in several other fields. The Board relies on this staff for help in the formulation of policy and for execution of programs planned. In the final accounting however, the Board must take complete responsibility for what is done.

The TVA is a unique experiment in the coordination of conservation activities in a limited area. First let us discuss briefly the kinds of dams and reservoirs built by the TVA in the Tennessee River and its tributaries and the necessary way in which they must be operated, for these have a very definite bearing on the problems of fish and wildlife conservation.

Nearly all the dams are relatively high ones, and the reservoirs are of the kind designated as ''multiple purpose'' since they are designed and operated for three major purposes, namely, to control floods, to provide for year-around navigation of the main river, and to provide falling water for hydroelectric power production.

The nine main-stream dams create a chain of reservoirs that form a navigable waterway extending from near the mouth of the river to Knoxville, a distance of some 630 miles. On the main tributaries there are many more dams and reservoirs.

Under the law, flood control and provision for navigation take precedence over power generation, and the TVA reservoirs are operated with this in mind. This requires the sacrifice of some of the potential power, for the months during which rainfall is apt to be the most plentiful, January, February, and March, are the months of greatest danger from large main-stream floods. The TVA reservoirs are deliberately held at low levels during this period. Thereafter the water levels in the reservoirs are allowed to rise, and the hope is that the reservoirs will be at high pool levels in late spring. During the dry season of the year water levels in some reservoirs may be lowered again as water is needed to maintain the navigation channel and to generate power.

The point is that the intended use of the TVA reservoirs requires that the water levels change during the year. The drawdown may be several feet in the main-stream reservoirs but as much as 150 feet in some of the storage reservoirs. The problems that these necessary drawdowns create with respect to fish and wildlife will be discussed presently.

Another group of problems in which fish and wildlife were involved arose when the TVA made the administrative decision that it was unquestionably necessary to control the incidence of malaria in the lower reaches of the Tennessee River where in some areas 30 per cent of the people were infected.

Several methods of control were eventually found necessary, some of them drastic when viewed from their possible effects on fish and waterfowl. One measure adopted was small periodic fluctuations of water levels, these timed with the malarial mosquito's life cycle and intended to create unfavorable conditions for the development of mosquito larvae. Arsenical (later DDT) larvicides and crude oil were sprayed from airplanes and boats on some of the shore areas where mosquitos breed. Another method adopted was to keep the shorelines free of debris and small plant growth by periodic burning. And one of the more drastic and effective measures adopted was to clear and straighten shorelines by cut and fill operations, supplemented in some areas by the building of dikes along the river. During high-water periods, many of the low-lying areas back of the dikes are flooded as a water storage measure, but, beginning in early May, when the water storage capacity is not needed, the water is pumped over the dikes and back into the reservoirs, leaving the areas behind the dikes to dry up and thereby cease to become breeding grounds for mosquitos. Likewise, these areas are denied to fish in the season when fish spawn.

This then was the situation: The reservoirs had to be drawn down to serve their normal functions, even if, as many of the Izaak Walton League folks and others loudly proclaimed, the fish could not reproduce in reservoirs so operated. The TVA felt morally obligated to control malarial infection in the Tennessee Valley by any means found to be feasible, regardless of possible harmful effects on fish or waterfowl.

This is, of course, not to say that the TVA was unconcerned with the welfare of fish and wildlife which are part of the natural resources of the region. But it seemed to many fish and wildlife conservationists that the drawdown of the reservoirs, the use of mosquito larvicides, the clearing of shorelines, the minor fluctuations of reservoir water levels, and the dikes that allowed shallow-water areas to dry up in the summer months, were all so inimical to fish and waterfowl that they could not survive in the region. The fish, they said, could not reproduce because their spawning places were no longer available; the fish would be poisoned by the larvicides used; the little fish would not be able to hide from their natural enemies; the migratory waterfowl would find their food supply areas along the shores burned over and poisonous larvicides lying everywhere. This was the gloomy prospect the conservationists foresaw with alarm and dismay.

Faced with these dire predictions which the TVA was unable to evaluate with any degree of certainty at that time, the Board made three important executive decisions. These were, in brief, as follows:

1. The TVA would discuss the situation with representatives of the U. S. Fish and Wildlife Service, the U. S. Bureau of Fisheries, the U. S. Bureau of Entomology and Plant Quarantine, the U. S. Bureau of Health, and with representatives of the corresponding organizations in the several Valley states. Many helpful and sometimes tumultuous discussions were held, the TVA endeavoring always to find out the factual data and experience on which opinions were based.
2. The TVA would begin an active, careful study of the unfolding situation, working with the above-named group, particularly with the U. S. Fish and Wildlife Service and the state organizations, the purpose being to replace unverified speculations with factual data.
3. The TVA, again in cooperation with the above-named agencies whenever possible, would take certain positive steps either to avoid the difficulties foreseen or to introduce favorable factors that more than balanced the unfavorable ones.

These were executive decisions made by the TVA in its early years. I shall now turn the calendar ahead some 15 or 20 years to say that today fish are abundant in the TVA reservoirs, and the Valley states have eliminated closed seasons and creel limits for fishing therein and again permit use of nets for the harvesting of rough fish. As for waterfowl, they regularly use the reservoir areas in great numbers and find plenty of food. It is worth while then to consider how these results, so contrary to early predictions, have been brought about.

Turning first to the fears and predictions of the fish and wildlife folks, I may say that the TVA did not believe that the direful results would necessarily come about. We knew that the folks who feared the worst had actually had no experience with a comparable situation, one in which there would be a great chain of reservoirs which would be regularly drawn down and where it would be necessary in some areas to apply drastic malarial control measures. The TVA also noted that in the summer when larvicides are used the ducks and geese are up north. Also it seemed then to the TVA that mosquito larvicides might be effective in concentrations too low to kill fish, and furthermore it seemed that with 10,000 miles of shorelines along the TVA reservoirs it was not likely that larvicides used in a relatively few areas could have much effect on total fish population even if all the fish in those few areas were killed. And it seemed then that food for migratory waterfowl might well be made available to replace that destroyed along the shorelines.

Giving some weight to the predictions that the reservoirs would become "biological deserts," and not being sure that such a prediction was in error, one of the first TVA countermeasures was to establish two fish-rearing facilities, one on some low-lying land below Norris Reservoir in Tennessee and one near the Wheeler Reservoir in Alabama. In a few years it became apparent, however, that it was unnecessary to use artificial stocking. The TVA fish-rearing facilities have long since been abandoned. Today some of the Valley states do a small amount of stocking, usually for the introduction of a new species for either sport fishing or forage.

The TVA's decision to have a good "look-see" as the situation developed has paid off. Fish population studies have been made at frequent intervals, and the waterfowl have been watched, and a great volume of factual information has been accumulated in the past 20 years. Even the alarmists—most of them—have shared with TVA in the educational process of finding out the facts.

Let us turn next to some of the other positive measures taken by the TVA and some of the facts that have been established as a result of the "look-see."

It was found that the adverse effects of drawdown on fish reproduction could be minimized if the drawdown were halted for a couple of weeks when shallow water temperatures in the reservoirs reach that favorable for spawning. This practice in reservoir operation was theoretically one of executive direction by the Board but actually it came about in the routine cooperation between individual divisions of the TVA staff.

Actually the drawdown of water levels in the reservoirs has some favorable effects on game fish. The exposed bottom along the shoreline is subject to weathering that disintegrates the organic debris and thereby furnishes nutrients to the new crop of plankton and other microorganisms in the spring. Without the drawdown, there would soon accumulate, particularly on the main-stream reservoirs, large masses of organic debris that would afford excellent breeding grounds for carp which are detrimental to game fish propagation. Another benefit of the drawdown is to destroy a lot of snails which are known to be intermediate hosts for fish parasites.

In using arsenical sprays, or DDT, or oil as a malarial mosquito control measure, it has been found in practice that no serious harm to fish population results. In the first place, the concentration of arsenic that is effective in mosquito control is below the tolerance level for fish. Moreover, as previously mentioned, the areas so treated are very small compared with the whole shoreline in any reservoir.

In view of the predictions with respect to fish welfare in the TVA reservoirs it is of interest to look at the specific results of one of the samplings, such as a recent one on Wheeler Reservoir. This reservoir covers an area of about 67,000 acres and has a shoreline of about 1,000 miles. The reservoir was filled in 1936. It is in the malarial danger region and has long been exposed to all the malarial control measures that were thought to be deadly to game production. Here is the score.

POPULATION STUDY—WHEELER RESERVOIR—ELK RIVER, MILE 7—MAY 19-20, 1955

Species	Number	% Total Number	Weight	% Total Weight	Size range (inches)
Largemouth bass	61	1.40	55.86	4.84	5-23
White bass	11	0.25	3.88	0.34	4-14
Yellow bass	7	0.16	1.87	0.16	5-10
White crappie	34	0.78	16.24	1.41	3-14
Black crappie	2	0.05	0.50	0.04	-
Bluegill	2,452	56.12	285.43	24.71	2-8
Longear sunfish	2	0.05	0.25	0.02	-
Green sunfish	181	4.14	5.31	0.46	2-7
Shellcracker sunfish	13	0.30	1.50	0.13	4-7
Orangespotted sunfish	111	2.54	1.11	0.10	2-5
Warmouth bass	67	1.53	4.61	0.40	2-8
Blue catfish	5	0.11	5.93	0.51	12-18
Channel catfish	66	1.51	39.74	3.44	5-24
Flathead catfish	10	0.23	5.36	0.46	5-15
Drum	339	7.76	57.18	4.95	4-15
Smallmouth buffalo	71	1.62	218.72	18.93	8-21
Largemouth buffalo	2	0.05	6.75	0.58	17-19
Carp	26	0.59	56.35	4.88	11-22
Spotted sucker	40	0.92	23.63	2.05	5-14
Redhorse sucker	90	2.06	90.52	7.84	5-17
Spotted gar	2	0.05	1.00	0.09	14-17
Gizzard shad	753	17.23	271.77	23.53	5-14
Mississippi threadfin shad	10	0.23	1.38	0.12	4-6
Minnows (Miscellaneous)	13	0.30	0.06	-	-
Lamprey	1	0.02	0.20	0.01	-
Total	4,369	100.0	1,155.15	100.0	-

Sample area approx. 1.5 acres treated with 1 ppm. emulsifiable rotenone
Weather—clear
Air T.—76°F. H_2O T.—76°F.
Maximum depth—14 feet
Mean depth—5 feet

If the Wheeler Reservoir surface waters everywhere contained fish in proportion to the area sampled (which is, of course, only a very rough assumption) the fish population of the reservoir would be about 200 million fish weighing about 25,800 tons. It will be noted that more than 67 per cent of the fish sampled were game fish.

The coarse fish in the TVA reservoirs support a thriving commercial fishing enterprise and this in turn favors the game fish production.

In the past year commercial fishermen harvested nearly 2,000 tons of coarse fish valued at more than $400,000.

It was feared at one time, and the TVA folks shared this fear, that the mussels, once so plentiful in the lower reaches of the Tennessee River, would not be able to live in reservoirs. But apparently there is enough movement of water in the now submerged original river channels to carry needed nourishment to mussels. At any rate, the annual harvesting of mussel shells continues apace. In 1954 the take amounted to 11,220 tons, valued at some $473,000.

In summary, the TVA experience has shown that under the conditions that prevail in the Tennessee Valley:

1. Fish can thrive in reservoirs that must be drawn down from time to time during a year with only minimal precautions to favor spawning.
2. It is desirable to encourage commercial fishing of rough fish in order to favor game fish production.
3. It is not necessary to impose closed seasons or creel limits.
4. It is possible to apply mosquito control measures, such as the application of larvicides, burning debris along the shorelines, diking off and drying up backwater areas during the summer, all with no appreciable bad effects on fish population.
5. There is enough water movement in the submerged river channels to permit mussels to flourish.
6. Stocking of fish is needed only to a very limited degree.

Let us consider next the waterfowl, including migratory waterfowl, that have discovered and now use the TVA reservoir regions. Here again, through executive decisions and their application, the problem of supplying food for ducks and geese during their migration or during their winter sojourn in the Valley has been satisfactorily solved. Fluctuation of reservoir levels during other than the winter months is not involved, since the Valley region is of no significance as a nesting area. But the reservoirs are also drawn down during the winter months, and furthermore measures are taken to keep the shorelines as clean as possible in preparation for malarial control program during the summer. The lake shores therefore do not offer much food for waterfowl. The TVA early reached the conclusion that if waterfowl were to find food it must be grown in areas independent of the reservoir shorelines. Fortunately, the situation along the reservoirs lent itself to the solution of this problem. In acquiring sites for the planned reservoirs the TVA, for a variety of reasons, bought more land than is normally covered by the reservoir pools. While most of this excess land has now been sold or transferred, the TVA still has need of much low-lying land for temporary storage of water in the control of winter floods. During the summer this land is available for agriculture and is leased to farmers, but the leases require that a part of the crop be left in the fields as food for waterfowl. This practice is followed both on the state and Federal refuges and on areas which are under the wildlife management of the Valley states (public shooting areas). In all some 19,000 net acreage of land is now used in waterfowl food production. On the refuges alone it is estimated that last year's waterfowl share of the grain crops amounted to about 50,000 bushels.

Aside from the state wildlife management areas (controlled public shooting), now totaling some 17,000 acres along the Guntersville, Wheeler, Pickwick, and Kentucky Reservoirs, the TVA has cooperated with the U. S. Fish and Wildlife Service and with the several Valley states in making lands available for waterfowl refuges. The first of these was the Wheeler National Wildlife Refuge, established by Executive Order of President Roosevelt in 1938 and managed by the U. S. Fish and Wildlife Service. The TVA originally turned over 42,000 acres of land and water for this use, but the area has since been reduced in size at the request of the Service. Since 1938 another refuge has been set up under the same management, namely, the Tennessee National Wildlife Refuge, to which the TVA has allocatd 50,000 acres of land and water. The TVA also allocated some 9,000 acres as an addition to the Kentucky Woodlands National Wildlife Refuge.

In addition to these national wildlife refuges, the state departments of conservation manage two waterfowl and wildlife refuges in the Chickamauga and Watts Bar Reservoirs covering a land and water area of about 8,400 acres, and one waterfowl refuge of 6,700 acres in the Guntersville Reservoir region.

Ducks and geese evidently find plenty of food in the TVA reservoir regions in the lower end of the Valley. At the peak of the migration season in December 1954 the U. S. Fish and Wildlife Service estimated that there were about 266,300 waterfowl there. Some of the waterfowl spend the winter in the Valley, for the estimated number of ducks and geese in the region on January 15, 1955 was 116,800 and on February 15 it was 85,100.

There are, of course, many forms of wildlife other than fish, ducks, and geese in the Tennessee Valley. Quail are found everywhere and manage to survive. Black and brown bear are numerous in the Smokies and, along with the bear in most of our National Parks, subsist mostly on garbage and illegal snacks provided by tourists. In roaming the National Parks and National Forests of the Valley one may, with luck, catch a glimpse of a wild turkey. There are also a few wild boar in the mountains and these survive in small numbers mostly because of very limited hunting seasons. Small birds are abundant and of many species. There are a few fox in the wooded areas, certainly too few to supply the numerous roadside vendors of fox furs. Squirrels are rather plentiful; rabbits are not as numerous as one would expect in such a region, perhaps because they have elected to live dangerously in the vegetable gardens of city dwellers. There are relatively few snakes, but amongst them are three species of the pit viper family. Deer are not plentiful, but they thrive if given half a chance. In 1936 the TVA liberated 13 deer on the 24,000-acre Central Peninsula of the Norris Reservoir. In 1947 the TVA leased this peninsula to the State of Tennessee as a managed wildlife area. Beginning in 1950 the area has been opened for a short period each year of controlled hunting. Last year 830 deer were taken legally by 1,149 hunters, and 150 were trapped by the states for stocking other areas.

In the foregoing pages I have mentioned the importance of legislation which defines objectives and provides a general pattern of operation but which wisely leaves to subsequent executive decision the ways and means of reaching the desired goals. I have described the system of dams and multiple-purpose reservoirs in the Tennessee River basin; the way in which these must be operated to meet the requirements of the TVA Act regarding flood control, main-river navigation, and power generation; the necessity of malarial mosquito control in the lower parts of the Valley; and the many problems with respect to fish and waterfowl created by these requirements. I have given examples of the many administrative decisions made in TVA's approach to these problems. This approach involved essentially the following policy: (a) that the TVA would work cooperatively with organizations interested in wildlife conservation but would launch fact-finding investigations rather than rely on guesses as to what would happen in a situation never before faced in a river valley, and (b) as the facts became available the TVA would take such steps as were necessary to protect fish, waterfowl, and other forms of wildlife.

I have told how this "look-see and then act" policy has paid off. Contrary to the fears and direful predictions of many wildlife conservationists, the fish populations of the TVA reservoirs have increased so rapidly that the Valley states have eliminated closed seasons and creel limits on game fish; commercial harvests of rough fish and the take of mussels in the far downstream reservoirs add considerably to the Valley income; waterfowl in great numbers use the reservoirs; national wildlife refuges have been set up on once TVA-owned lands now controlled by the U. S. Fish and Wildlife Service; and managed wildlife areas under control of the various Valley states have been set up at several places in the region.

In the course of the past twenty-odd years, much has been learned regarding wildlife protection under the unique conditions created when a great river basin contains a long chain of reservoirs that must be drawn down at times and where malarial infection must be controlled. The experience gained in the Tennessee Valley will certainly be useful in other situations where sound legislative action, administrative decisions based on carefully established facts, and effectively executed programs are needed in the conservation of wildlife.

I have naturally chosen to speak on this occasion only of the TVA's experience in the conservation of the fish and wildlife resources of the Tennessee Valley. But there are many other natural resources with which the agency has concerned itself, and where administrative direction, coordination of activities, and cooperation between groups having divergent interests have been developed to solve the problems presented. The moral of my story is that most of the problems that arise in the conservation of natural resources can be solved if the folks concerned are willing to find the facts and then seek the best overall procedure that will bring the most good to the largest possible number of people.

GETTING COORDINATION IN CONSERVATION BY THE "PILOT" DISTRICT WAY

HARVEY S HALE

Chairman, Public Lands Committee, National Association of Soil Conservation Districts, Rogerson, Idaho

Dear Fellow Conservationists:

Now don't get excited by that salutation from a cattleman from the West. No, I am not trying to pull a Trojan-horse deal on you. I really mean fellow conservationists, and I know that this is the feeling of a big majority of the livestock people of the western states. That old feud between the wildlife people and the livestock people is just as much out of date as the old cattlemen versus sheepmen wars of the past. We, all, have too big a job to do to waste our energies bickering or fighting among ourselves.

This most sacred and patriotic duty of making this land better for the future generation by our having used it, should overshadow all our activities.

I had better hesitate a minute to tell you why and how I, a plain old cowpuncher, am here on this program among all these V.I.P.s, *i.e.*, presidents, vice-presidents, secretaries, deans, professors, directors, editors, chiefs, and what-nots. Most of us cattlemen are V.P.P.s these days—very poor people.

The National Association of Soil Conservation Districts and my wife have made it possible for me to be here. The National is footing the bill and my wife is feeding the doggies.

Your organizations, the Wildlife Management Institute, and our National Association of Soil Conservation Districts have had the best of relationship and we certainly appreciate the help that we have obtained from you. Our objections are so dove-tailed that each is benefited by the activities of the other. When we get conservation of soil and water on private and public lands, we materially assist in the restoration and conservation of wildlife and when you, through your educational and legislative program assist in the conservation and improvement of our public lands, you are helping our western Soil Conservation Districts in their programs.

The National Association of S.C.D.s certainly wants to thank Dr. Gabrielson and Mr. Gutermuth for this opportunity of discussing our mutual problems. "Gabe" and I gave mole trapping demonstrations in Coos County, Oregon, away back in the twenties. Our next field trip was two years ago when he visited our Nevada "Pilot" District. He still believes that the six fat antelope grazing on a reseeded area of crested wheat grass were a plant.

Any of you who is interested in the western public lands program should read Mr. Gutermuth's recent address given at the Denver meeting of the American Society of Range Management.

Over 2700 Soil Conservation Districts, covering 90 percent of our land, compose, own and operate the National Association of S.C.D.s. More Districts are rapidly being formed and we hope to make it 100 percent of all our land in Districts in the near future.

Pardon the repetition to many of you, but we still find so much confusion regarding Soil Conservation Districts, that I will briefly tell you in a cowman's language what one really is. A Soil Conservation District is a sub-division of a State government, brought into being by a group of farmers and ranchers who have soil and water problems that they cannot solve as individuals. The area may be a community, a county or several counties. The sole purpose is to assist the people with soil and water problems, the same as a school district sponsors the education of our children and a road district facilitates our traveling. Like these two, a Soil Conservation District is governed by an elected board of supervisors, directors or commissioners. No better example of self-government can be found. A Soil Conservation District is not subservient to anybody except its own people.

Under State laws it can ask the assistance of any local, state or federal agency. The Federal Soil Conservation Service is the agency giving the most assistance to Soil Conservation Districts but the Bureau of Land Management, Forest Service, Fish and Wildlife Service and the different State Fish and Game departments are materially assisting Districts.

Now with the preliminaries over, let us get down to the story of how our western Soil Conservation Districts and especially our "Pilot" Districts have and are getting coordination and cooperation in conservation of soil, water and wildlife.

The story began back in 1951 at the 5th Annual Convention of the National Association of Soil Conservation Districts at Oklahoma City, when the late A. H. "Speed" Agee was successful in getting a Public Lands committee appointed and his "Pilot" District coordinated land use program sponsored by the National. He then went to Washington, D. C., to explain his plan to the heads of the land managing agencies and received a very favorable reception.

"Speed" had so thoroughly thought out his plan and talked it over with his other District supervisors that to this day very few ways of improving it have been found. His keen knowledge of the subject was acquired by having been reared on a cattle and sheep ranch in northeast Nevada, by having worked for the Bureau of Land Management and the University of Nevada Extension Service and by having operated a large cattle ranch for himself and his family. He could see that there was no coordinated effort on the part of the private land owners or the Federal land managing agencies to correct the continuous depletion of our precious soils and ranges. That is why in 1948 he single-handed got the ranchers together and organized the Northeast Soil Conservation District.

The Bureau of Land Management personnel seemed to be fully occupied with their policing efforts and some of the local personnel of the Bureau still seem to think policing is their major duty. The Forest Service, which had been in operation considerably longer, had good ideas about improving the lands under this jurisdiction but had been unable to get popular support. Departmental jealousies seem to keep the agencies from working together. The results of research and experiments was not exchanged nor accepted by some. It was really a hell of a mess and the lands were getting all the hell.

The essence of his program was two-fold: first to have all groups of our population having an interest in these lands represented and working on the program and second, to have all land managing agencies and the land owners working together on a coordinated land use program for all the lands in the District.

To get the program started "Speed" arranged for a meeting of all interested parties, with the following represented: Nevada State Fish and Game Commission, sportsman's organizations, water users, Nevada State Association of Soil Conservation Districts, Bureau of Land Management, Forest Service, Indian Service, Fish and Wildlife Service, University of Nevada, Nevada Farm Bureau and the Nevada Cattlemen Association. The results of this meeting were that the Northeast Elko Soil Conservation District was chosen as the best District to carry out this demonstration of proper land use and an advisory committee with one representative from each of the agencies and groups was appointed to get the ball rolling. Within two weeks this advisory committee had a three-day meeting and worked out a complete and detailed program.

Well do I remember the dates, April 10, 11 and 12, 1951, because on returning home from that meeting our leader, "Speed," was killed in an automobile accident. It then became the duty of the rest of us to carry on.

To proceed with such a program there are several steps that must be taken, *i.e.*, first an inventory of all the resources—land, water, game and fish and vegetation; second, what needs to be done to bring these resources up to their maximum efficiency; and third, the methods and the necessities for doing the job.

To obtain this information, a work group consisting of representatives of the Nevada Fish and Game department, the Bureau of Land Management, the Forest Service, the Soil Conservation Service and the District Supervisors were appointed and instructed to start work immediately. This was a big job—two and one quarter million acres in our District and about three-fourths of it federally owned. It took about six months for this group to complete the job and it was certainly worth it. We really had the information needed.

I am not going to bore you with a lot of figures but I do want to tell you that we are getting a lot of conservation and development done. No, not as fast as we would like, due to lack of available finances from the ranchers and the meager appropriations for the land managing agencies.

The Bureau of Land Management with 180 million acres to administer puts 239 million dollars into the Federal treasury while only 12 million was appropriated to spend. Which means this Bureau made the government 20 times the cost of its operations. I only wish my ranch would do one twentieth as well.

The Forest Service also makes money for Uncle Sam with revenues of 108 millions and actual expenses of around 50 millions. These revenues do not include the unestimable value of these public lands for watershed and recreation.

In the first four years of this program over sixty thousand acres of depleted range land has been reseeded, miles of fences built, stock and irrigation wells drilled, reservoirs, and ponds constructed, farm land leveled and irrigation systems improved. We are making a better country in which to make a living and go hunting and fishing in.

All the other ten Western States have "Pilot" Districts with similar programs. In Nevada three other Soil Conservation Districts are already working on a coordinated land use program. Our "Pilot" District has led the way so that others may follow. It's hoped to have all the Soil Conservation Districts containing public land get going on this proven method of conservation in the next few years.

One of the secrets of success of this procedure is getting the local people sold on the idea and then have local sponsorship and leadership.

So far everything has been rosy according to the picture that I have given you but it wasn't that easy. We had a lot of obstacles to overcome. Some of the ranchers could see only another government control. Some of the agencies were afraid of losing some of their prerogatives. Some of the personnel were not favorable because the people were helping win the show. This was all overcome when we got all concerned around a table and when necessary went right out on the ground. Very few obstacles are insurmountable when there is a will and a way to do good.

Now in conclusion (aren't those sweet words in any address) let us see what our Soil Conservation Districts are specifically doing toward the conservation and restoration of fish and game. Here is what we ranchers of the Northeast Elko District think, as I will quote it direct from our program—"The production of wildlife is considered to be the second most important interest in the District." The reseeded areas are taking the pressure off of the higher browse ranges where the deer feed. Deer and antelope both seem to like the crested wheat grass in the spring and also in the fall. It is the first to green up in the spring and stays green the latest in the fall. Deer have really increased in our area. There are fifty deer now where there was only one twenty-five years ago. This last season each hunter was allowed two deer. Fish and waterfowl have increased due to construction of ponds and reservoirs and the stabilization of streams.

A large number of our western Soil Conservation Districts have working agreements with the Fish and Game Departments and are carrying out excellent programs.

A large majority of our western ranchers really like to have fish and game around. We will have friends coming out to our ranches to fish and hunt. Some ranchers make more out of hunting than they do out of their cattle. And last we are smart enough to know that sportsmen out-vote us one hundred to one.

I thank you.

RESOURCE ECOLOGY—NEGLECTED DISCIPLINE

DURWARD L. ALLEN[1]

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Creation of a sound strategy in resource use is perhaps the most important thing we Americans can do for ourselves. On this hinges national strength and individual welfare.

The urgency is hardly questionable, with today's population of 165 million growing at the rate of 2.5 millions per year. The Census Bureau considers it possible that we will have 221 million people in the United States by 1975. It seems fair to ask, what kind of life will these millions have?

This is a public problem and a concern of government. Accordingly, we have had researches and compilations by a variety of boards and commissions attempting to plot our path to the future. They have dealt with "national planning," forestry, land use, materials policy, water control, and other segments of the resource field.

The specialists employed have been of the best, but characteristically they are specialists, and each is limited to his own terms of reference. "Production" and "development" are the common goals; but seldom is there any questioning of what it is proper to produce or the final aim when we develop.

One looks long in the massive reports for any interpretation relative to ultimate human weal. There is a common tendency to regard the population increase as a dissociated act of God. Living standards are conceived as the challenge to our ingenuity in endlessly multiplying the products of assembly lines. We seem to be so busy constructing the implements of civilization that we neglect to review its motives.

I have no thought to discount the benefits from competent, if piecemeal, studies of resource logistics. But we are failing in the final synthesis of this problem, and the failure grows in gravity as the square of the time we lose.

[1]In the absence of the author, this paper was read by Dr. C. M. Kirkpatrick.

Seldom, if ever, has there been any officially sponsored recognition of an inverse relationship between numbers and living standards at higher densities of the human species. In fact, the opposite assumption is implicit in programs advanced. They identify maximum numbers with higher consumption, higher consumption with more business, more business with greater "prosperity," and this, in turn, with better living for the individual.

Visible policy seems not to acknowledge that what we do with all resources in North America should somewhere have analysis as a single *biological* problem. The wildlife scientist observed long ago that animal numbers are a function of environment. He has seen endless repetition in Nature of the truth that health, comfort, and social welfare among all creatures are found in good environments stocked to moderate, rather than maximum, density.

It would be a strange exception if this did not apply equally to humans. It is inescapable that our management of resource capital on this continent will be a determinant of our own future numbers. Since numbers are involved with living standard, in the equation of values, quantity and quality will appear frequently as alternatives.

These premises are biological, and it is understandable if they have been left out of the planning of engineers, lawyers, businessmen, and economists. Population and resource dynamics have been slow to gain recognition as a field of technical study. But this is a phase of *ecology,* the science concerned with relationships of living things to their environments. In our interest, it will be curious indeed if we do not acknowledge the future of humanity to be our most critical ecological problem.

Scholars of our time frequently deprecate the failure of science, socially and politically, to match our amazing progress in mechanical fields. In reality, their regret is for our inability to apply the most elemental knowledge of human ecology.

Actually, the science is available, but ignorance, mores, and politics are much in the way. The proper breed of biologist never seems to make himself heard in the government. Administration is compartmentalized, and the biological phase of a resource plan can hardly be evolved until the problem analysis is complete. A recognition that something is wrong finds occasional expression in recommendations for a non-partisan natural resources review board to function at Cabinet level. This too would involve difficulties, but there would be no better place to apply the knowledge of the resource ecologist.

In this estimate of our population-resource prospects, I make no pretense of evaluating the social, cultural, and political factors that will influence our growth in numbers. Over the long haul, these are largely unpredictable, as our most able demographers have learned. But certain biological assumptions are admissible: A population does not grow in thin air; it expands with reference to a resource base. It has the *potential* to expand indefinitely, but this potential is not expressed because all environments are limited.

We will do well to perceive that our human habitat in North America also is limited, and that obstinate faith in a perpetually "expanding economy" can do nothing to alter the situation. Our population, like all populations, must level off somewhere because space and resources are not endless. The crux of the matter is that by foresight and realism we can exert some control over the kind of life we will have after the ultimate development in numbers is reached. For this much of an analysis, we do not need to foretell the progress of science, birth control, education, production, and utilization.

We can, in fact, largely restrict consideration to the nation's "renewable" wealth—soils, water, forests, grasslands, wildlife, and recreational areas. These are a particular issue, since management alternatives may range all the way from quick and easy liquidation to long-range building up and cropping. Often enough, the interest of presently influential minorities opposes the claim of generations unborn and unrepresented in person.

My present thesis is concerned, ulitmately, with one thing: the future living standard of Americans. I assume that a comfortable and dignified existence is our most respectable motive in managing national wealth. If that is true, then we must apply discrimination in identifying things that are important to us and see that they are preserved in usefulness for the future.

With this motive and this approach, the ecologist must inevitably call to question a major—and certainly the most expensive—feature of our present resource management. Specifically, it is the payment of large public subsidies to bring more land into the production of basic crops.

The logic of this situation develops in four steps:

(1) That the costs are high and a tax on our present living standard.

(2) That we can not outrun the population increase by opening up new areas.

(3) That the conversion of marginal and submarginal lands to agriculture will result in a higher continental population and thus increase pressure on all resources.

(4) That subsidized land "development" is destroying important

features of our out-of-doors—recreational assets which become more critical with each increase in human numbers.

For present purposes, it will be convenient to conceive of our use and development of land and water as taking place in two phases. Both can be seen in operation.

USE ACCORDING TO CAPABILITY

What we will call "phase one" consists in using the nation's land and water areas for the kind of production to which they are naturally and most easily adapted. In line with this, nearly all fertile soils of favorable topography have been pre-empted for agriculture. Other, less durable, areas will yield most in trees, and still others have primary usefulness as stabilized watersheds, grazing ranges, or wilderness recreation lands. In scientific land planning it is an accepted guideline that deterioration should not be tolerated, and improvement in use should be possible.

We have seen this kind of zoning, according to land capacity, in some of our government programs. The extension and refinement of such work should bring land management on a watershed basis, with "multiple use" a guiding principle in most, but not all, operations. A sound and comprehensive effort of this kind would bring about the rehabilitation of damaged lands or their retirement to less intensive uses. It would require the cessation of pollution in practically all our waters. An ultimate criterion of success would be the mitigation of such costly disasters as "dust bowls" and floods.

Such a protective program is our true frontier in the use of what is ours. It can save what we have against waste at minimum cost. It requires an understanding and employment of the ecological relationships among soil, water, vegetation, and animal life. Planning with the long-term view has been characterized as "working with Nature." For now, we will consider it to be a program in which *no premiums in public money would be spent to bring new acres under the plow.* Private improvements at private cost can be taken for granted.

Applying such a policy would tend to stabilize agricultural acreage. Of course, many people would object to this on the grounds that, within a few years, we will have used up our crop surpluses and will need every possible acre to provide necessities for the population and business opportunity for more people.

This is a common viewpoint, but it fails to perceive the dynamic nature of human numbers. Each new area we "develop" will be a basis for new population increases. Thus, the slack will be taken up, and each time we run out of space, the density, the pressures, and the problems will be there again—on a larger scale.

I think we can be certain that, on another basis, our population build-up will be sufficient unto the day. The continuation of technical progress will make the land we have steadily more productive. And when we have reached the end of that, there is no reason to discount predictions that science will extend the feeder roots of our population into the oceans and unlock a vast store of benefits.

In effect, this will continue to expand our resource base and the carrying capacity of our "range." It will be a foundation on which numbers can be expected to build—how much, no one knows. Cultural factors could bring a leveling off and reasonable stability at a fairly comfortable density. Or it might be otherwise, and such social virtues as faith and optimism are not involved.

"CONQUERING OUR FRONTIERS"

Now let's consider what I will call "phase two" in our resource development. It is the great and grandiose reclamation movement, and it is taking place with headlong rapidity. It is characterized by the venturing of major sums of public capital, obtained by taxing naturally productive areas, in the "development" of marginal and submarginal lands in order that these, too, can be made "useful to our people."

Irrigation and drainage are the techniques most frequently featured in reclaiming land for farming. Irrigation on the grand scale—the kind where public money is hazarded—will involve, or be accompanied by, the remodeling of western river systems, early utilization of available dam sites, construction of wilderness power plants as a speculative basis for industry, the building of flumes to conduct strait-jacketed streams across and through mountain ranges, and finally, the watering of thirsty soils to make a garden in the desert.

Huge budgets and still larger expenditures always have been characteristic of these programs. Our population has expanded into all naturally productive lands, and private initiative has handled most of the development that could be done at reasonable cost. Now we hear that expansion must continue by adding unreasonable costs to the public debt.

In his study of past government reclamation programs, Raymond Moley[2] found that the repayment record was "indescribably bad." He indicated that "The ultimate cost to the taxpayer is and will remain for generations indeterminate" or until "some Congress, weary and disillusioned but generous, will write off the whole thing."

[2] *What price federal reclamation?* Amer. Enterprise Assoc., 1955, pp. 72.

I am concerned here with the ultimate effects of these programs, rather than their details. But cost obviously is a concern when we are dealing in billions to be paid by citizens of the future. As a sample of what may be in store for us, we can consider the Upper Colorado River Project, which came before the last Congress and will be featured business in the present session.

This amazing proposal to work over the entire Upper Colorado basin would involve the building of six major dams. The construction budget is 1.6 billions. But this does not include "forgiven" interest. Computations of the ultimate tax liability are around $5 billions. This assumes that the construction cost will be as represented, although Moley found that past estimates have been short in the ratio of 1 to 3. The wondering taxpayer concludes that no one really knows how much it will cost; but based on the figures given, the Tax Foundation determined New York's share of interest subsidies alone to be more than $493 million, California's $372 million, Pennsylvania's $277 million, Ohio's $236 million, Michigan's $196 million, Indiana's $102 million. We must reflect what all these millions would buy in schools, highways, swimming pools, and community centers.

In the proposed program our tax dollars would be buying more agricultural acres at the price of some $640,000 for each new 160-acre farm. The former Governor of Wyoming, Leslie A. Miller, a member of both Hoover Commissions, computed irrigation costs for eight of the 14 projects that would be served. The lowest cost per acre is $383 and the highest $1719. These figures would apply to lands which might attain a top value of $240 per acre. Other studies have shown that, if we needed more crops, it would be more economical to make an investment in the improvement of good agricultural areas where farms already are operating.

In totaling the price of certain dams in other river systems we will need to write off salmon runs that might have been cropped for all time to come—a kind of interest bearing that is difficult to appraise. The next century will see many of our costly reservoirs full of silt. A Department of Agriculture survey indicated that one reservoir in five will have a useful life of less than 50 years. We may ask: What pressures will develop from communities dependent on "government" water when the pipelines run dry? The dams may be evidence of engineering genius, but failure to control watershed erosion is another convincing testimony to our ecological ignorance.

There is no need to discuss the 7-billion-dollar hoard of surplus crops to which our added acres contribute and for which the public must pay in many ways. Our lawmakers now are considering plans for retiring about 40 million acres from crop production to cure this surplus problem. Is it then good business to continue our subversion of the great open spaces?

Dollar costs of the great programs are an awe-inspiring liability, but they are not the ultimate folly in our scramble to grub off the natural scenery, put "idle" acres to work, and make the deserts bloom. The ecological effect may last even longer than the debt, for one product of the blooming deserts will be new populations of people, who will make new demands on all resources. The additional crop acreage will be still another broadening of the resource base on which human numbers will build.

What the taxpayer really is buying with his squandered dollars is an America of the future crammed to the waterline with citizens who will be forced inevitably to a lower standard of living. They will be competing for a livelihood in a country totally developed for subsistence crops. They may have enough to eat and clothing to wear, but they will have lost many of the benefits of life in America as we know it.

In this connection, we may logically consider the matter of drainage—our other major program to convert to "usefulness" a category of land commonly considered to be "idle."

In the United States more people go hunting and fishing than engage in all spectator sports combined. The annual business turnover dependent on the taking of game and sport fish is more than 9 billion dollars. Yet, while the U. S. Fish and Wildlife Service and all the states have been spending public funds to preserve and increase this recreational resource, agricultural agencies have given it short shrift in their well-nigh total consecration to the bulging granary.

For the past 20 years, and before, breeding grounds of the bulk of our North American waterfowl have been greatly diminished by marsh and "pothole" drainage in the northern prairie states and adjoining Canadian provinces. In this country, government subsidies have been paying for about half the cost of drainage. A recent wet-land survey of the Fish and Wildlife Service indicates that in the Dakotas and Minnesota alone these critically important marsh areas are being destroyed at the rate of some 32,000 a year. Unless this trend is halted, few of them will be left by 1975.

In practically all our agricultural regions, duck marshes and fishing lakes are disappearing, year by year, as we watch. The public funds which contribute to this are buying more crops that are not needed and less of the shooting and sport fishing for which there is an ever-increasing demand.

Furthermore, the Department of Agriculture has reported that east of the Great Plains there are about 21 million acres of undeveloped, fertile land which can be drained "profitably" for farming. Texas has nearly 4 million acres, and Louisiana and Arkansas nearly 3 and 2 million respectively. Other states with more than a million acres are North Carolina, Georgia, Florida, and Mississippi. This listing should be a rude jolt to a knowing duck hunter, since these southern states are the principal wintering ground of our eastern waterfowl.

No species can survive destruction of its habitat, and on both summer and winter ranges that habitat is now under onslaught by the draglines. It is a fair question, and one that leadership should have resolved long ago: Is it national policy to eliminate duck hunting?

What Is Our Living Standard?

These considerations lead naturally to another question, of what constitutes our American living standard? Is what we are losing an important part of it? If so, what would be constructive policy for keeping it?

To people of many nations we probably are distinguished above all else by the quantity and quality of our gadgets. These we will continue to have and to improve; but we will need the right kind of world to use them in or they will have about the same significance as a washing machine in a slum. Until now, our world has been good because we were a population expanding to fill a large and rich environment. History attests that such times are inherently prosperous.

Many Americans, who consider themselves "progressive," believe that the kinds of recreation which depend on golf courses, gymnasiums, movie theatres, and television sets can take the place of outdoor living. But this idea is denied by the 96 million recreational visits to our national parks and forests last year. It is refuted by the 18 million fishermen and 14 million hunters who bought licenses. Each year sees a truly startling increase in these figures. The people of this nation are not losing their interest in the out-of-doors. Their demand is increasing while the means of gratifying it steadily decline.

Present trends provide ample vindication of the policy, started by several courageous presidents, under which certain lands have been reserved for ownership and use by the whole people. Yet there is increasing attrition against these areas, and we probably are getting only a sample of what is to come.

In the West it seems almost a principle that public lands must be grazed irrespective of prior rights and uses. Herds of livestock persist in our National Parks. Each session of Congress sees a new attack by the 19,000 permit grazers who are bent on taking outright ownership of ranges they are now privileged to use on National Forest lands. This issue has been decided before, but the decision does not seem to stick.

The National Wildlife Refuges are about 260 in number, totalling some 18 million acres. They were established to accomplish specific purposes essential to the well being and management of migratory waterfowl and certain rare and interesting members of our fauna. But in spite of this clear-cut dedication, these units of land and water are under unremitting demand for other uses. Attempts have been made to turn some of them into bombing ranges. ''Homesteading'' has been, and still is, a threat to critically important areas. And now the bulk of the refuges have been opened to oil and gas exploration. Some public officials do not seem to take seriously their implied function as guardians of the public estate.

Blocking out ownership in public areas is increasingly difficult, and it comes ever at a higher price. In-holdings in the National Parks persist for decades after they should have been liquidated. The overloading of parks makes it clear that we need more of them and better maintenance of the ones we have. A small portion of the huge reclamation budget would do this magnificently.

The growth of these difficulties is an expression of the competition which comes with greater numbers of people. There is no reason to expect the trend to change.

POLICY AND THE FUTURE

It is hardly to be doubted that ''living space'' and what goes with it have been one of the features of the American blessing. It has eased competition and made many things available for the taking. More particularly, we have been a nation with a hinterland, which we draw upon casually and which has yielded benefits we are beginning to perceive.

It is a natural eventuality that, if unchecked, population increases and the demands of people under pressure would take over every area and every asset that could be put to any kind of profitable use. On the other hand, there are two policy lines in resource management which can assure a measure of elbow room, relaxing space, and other benefits. Population-wise, no one can estimate their ultimate effect, but it would be in the direction of limiting numbers.

One such policy would apply to parks, forests, scenic areas, and recreation lands and water of every description. It would require or affirm local, state, or national ownership of properties which need long-term management for the use and benefit of the whole people.

The second policy would be merely to withhold the huge expenditures now being made in public programs to put new land under civilization. It would be a unique program in this modern world that would accomplish great social benefits by merely saving our money, but that is how the matter stands.

The advance of civilization seems to be the progression of our culture toward a more pleasant and dignified level of living. It would appear that our most unselfish hope for the citizens of a century hence is the continuation of our ideal of life and liberty, coupled with increased means and leisure for the pursuit of happiness. In other words, we may wish for our kind that technical advancement will be rewarded with higher and higher standards of living.

In 1952, the President's Materials Policy Commission submitted a five-volume report containing abundant facts on available and potential supplies of national wealth. At the outset, in a discussion of "fundamental concepts," the committee affirmed its unshakable faith in "growth."

This is admissible and essential in a qualitative sense, as applied to the betterment of living. Quantitatively, it is in the same category with perpetual motion. Under whatever guise, today's programs are operating on a quantitative basis. Production, development, and reclamation have become the sacraments of an expanding economy fetish that we pursue blindly, refusing to see the limits of things that are limited and denying the potential of things that are limitless. In our industrial footgear, we are attempting to outrun the flood of human increase, with no high ground in sight.

It would be short of realism not to acknowledge that reduction of the birth rate in underprivileged segments of the population would cure a world of social ills. There is progress in that direction, but whether it can be effective in time is problematical. It is true also that no provisions we can make will avoid the great economic and political pressures that are developing against public property of all kinds.

Yet it is clear that we no longer have an incentive to "develop" everything at any cost. My proposition that such development would be unwise is founded on what seems to be a reasonable assumption: that a larger range will grow more people than a smaller one, and that the larger area, devoted primarily to subsistence production, will lack many things that Americans have considered important.

If there is no more to life than living, if human beings are content to accept numbers as a goal and be produced like broilers in a battery, served for essentials by a completely synthetic environment, then our present course is the proper one. Possibly the perception of the average person can be so narrowed as to make that kind of existence possible. But there seems to be no good reason why it should.

DISCUSSION

CHAIRMAN McGLOTHLIN: I don't think that we should ask Dr. Kirkpatrick to comment on the statements in the paper for they are not his statements although, I believe, he is in general agreement with them. However, if there are any comments that you would like to make on the paper, rather than questions to Dr. Kirkpatrick, then that would be all right.

MR. HALE [Texas]: I think that it would be a pleasure to get some of these doctors and professors and others who rant and rave about our western problems to come out and go over the ground with us and really see what we are doing with regard to correcting some of these things and how we are protecting the interests of almost all concerned. I think that if some of these writers would come out and look over the ground that their papers would have a little different tone to them.

CHAIRMAN McGLOTHLIN: Are there any other questions?

I have asked Dr. Cox to summarize the session. He did not expect to do this and so I don't know whether he is prepared to do it. However, I am going to ask him if he has anything to say.

VICE-CHAIRMAN COX: I don't know whether I am up to that job or not but I will give you a few personal comments for what they are worth.

As has been pointed out to you, the first three papers represent almost a unit—the three categories of a unit—that of training and research, of legislation and of executive direction. I could not help but be overcome by the fact that these three as a group were almost a perfect ecological study in the pure sense of the word "ecology," the relationship of things one to another. It appears to me that all of these ideas should be included in the training program—the program of education of the people and education of the students.

We then had the last two papers, which also were very well pointed.

The one undercurrent that runs through all of these papers is the need for education. I think that essentially each of the speakers got back to this basic need of education and the broad things that can come from it.

CHAIRMAN McGLOTHLIN: Thank you very much.

I would now like to return to the comments that I made at the beginning and this is simply another way of saying the same thing that Dr. Cox already has said.

In the beginning there were several assumptions suggested and if we are to take the papers as evidence and also your comments as evidence then I think that now we have some test as to the validity of those assumptions.

As best as I can interpret the papers, they all say that coordination, whether voluntary or enforced, is desirable, and so the first assumption of this topic seems to me to have been tested and found valid.

I also think that most of the papers would point to the second assumption and tend to validate it. That assumption, of course, was that we do not have it at present. It is desirable, but we do not have it.

The third thing most of the papers were optimistic about, is that we can get it. Dr. Cox has referred to education. I sit in at a lot of meetings and get a little worried when I hear the word "education" because we know it but then we do not seem to do anything about it. I feel that if it is a job for education then we have the further requirement that we put into administrative terms as to how you get that education. This is something that makes you comfortable—a word that makes you comfortable, for we do not think it is controversial. If it is a job for education then let's get it done. I think that the papers were optimistic in saying that we can get it and therefore they have suggested at least two ways in which we can get it. One of them is through education and the other by emphasis on a national policy which would help guide the individual efforts of federal and state institutions.

I was particularly struck by the fact that the commission that Mr. Taylor suggested was to include all of these levels of government so that when we arrived at a policy it would be a good policy rather than a limited one.

I wish to express the thanks of the organization to those who presented these papers and I would like to particularly express my personal thanks to Dr. Cox.

GENERAL SESSIONS

Wednesday Afternoon—March 7

Chairman: HARRY D. RUHL
Chief, Division of Game, Department of Conservation, Lansing, Michigan

Vice-Chairman: JAMES W. KIMBALL
Director, Division of Fish and Game, Department of Conservation, St. Paul, Minnesota

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INTERNATIONAL TEAMWORK IN WATERFOWL MANAGEMENT

CANADA'S PLACE ON THE TEAM

W. WINSTON MAIR
Chief, Canadian Wildlife Service, Ottawa, Canada

I am not an exponent of the game of football, so must stay away, to some extent, from too close comparisons with it in the present panel discussion. We are, however, an all-star team, drawn from state, provincial and two federal agencies, as well as some private agencies, and we have suffered from the lack of team practice that plagues all such teams. But we have been at this some time now, and we should be improving our teamwork. We should be prepared to forego personal high-score ambitions, prima donna notions and local jealousies. We must be prepared to examine what is best for the team and the continental population it represents, and then play our parts to the full.

When I speak of the Canadian part in the International Team, it must be borne in mind that Canada has two jurisdictions—provincial and federal, just as the United States has both state and federal authorities. It is difficult for me to speak for the provinces. They have their own needs and problems and are full partners in the game. However, I shall attempt to portray the situation as I see it, and to point up in general terms the place we Canadians can fill.

Let us first examine the objectives of the International Team. Our purpose in waterfowl management is to perpetuate the sport of waterfowling, at the highest practical level, for all our people for all time. Within this general scheme there will of course be local or regional needs; necessarily therefore there must be local priorities and peculiarities to take into account in the work to be done. Thus in the United States distribution of birds from northern breeding grounds to the various states is of paramount importance. Numbers of birds available must be known, in order that the harvest may be proper and equitable. Data on harvesting are a "must." Development of wintering and migration refuges is important. Increase of local breeding populations is highly desirable to meet the needs of increasing human populations, as well as to ameliorate losses to the duck population when drought hits the breeding grounds in the north central United States and the southern areas of the Prairie Provinces.

In Canada the immediate priorities are somewhat different. Certainly we are keenly interested in distribution of birds from the breeding grounds, especially from the northern areas. Kill statistics are very important. Development (or improvement) of breeding habitat in some sections of the East is desirable. Generally speaking, however, when we have plenty of waterfowl we do not need an exact census of their numbers; it is enough to know their relative abundance from year to year. We do not at present, in the west at least, need to develop refuges for migrating birds or to protect their breeding grounds. We are, however, very much concerned as to what the picture will be if drought conditions such as we had in the 30's should again occur. We need to know what management procedures would ensure some hunting, or at least maintain adequate brood stocks, in that event, and what refuges should be established to help the waterfowl to survive another long drought. We need to foresee what our policies will be when our human population has doubled—at which time pressures from the south of the line will be intense. We need to know much about individual waterfowl species, against the day when management will reach the level of differential regulation and harvest by species, and when pressure of agriculture may make it impossible to manage all waterfowl as a unified resource. We need to know very much about our northern areas and the waterfowl raised thereon. We cannot be complacent about the present, but our gravest concern is for the future.

In order that you may more clearly appreciate the Canadian picture, I shall outline briefly the areas of responsibility allotted to provincial and federal wildlife agencies. The British North America Act, by which Canada was created in 1867, made no specific mention of wildlife, but it did allocate certain responsibilities to Provincial

Governments and others to the Federal Government. To some extent the basis of division was separation of things of local importance from those of national importance. Natural resources generally have been recognized as being local, and their management is a provincial responsibility. Thus by mutual acceptance wildlife has been deemed a provincial concern. Crown lands, upon which much of the wildlife is found, are with minor exceptions held in the right of the Provinces.

By the terms of the British North America Act, however, matters which are the subject of international treaty are handled by the Federal Government. Therefore the Migratory Birds Treaty of 1916 brings waterfowl within the administrative responsibility of the Federal Government. You will see the apparent anomaly that this creates: migratory birds are a federal concern, but they are the property of the Crown in the right of the Province in which they may at any time reside. Thus their management might be construed as a provincial responsibility. This difficulty must be solved in the not-too-distant future, as active management will become increasingly necessary in the face of increasing human populations. In present practice, however, things work out pretty well, with all agencies cooperating and meeting in conference to settle matters of regulation, including seasons, bags, etc. The Act and Regulations are federal, but changes in them are made only by federal-provincial agreement.

How then can Canada best fit into the team? We encompass within our borders the major portion of the breeding grounds for both ducks and geese. Our principal contribution must be to maintain these for posterity. There can be little hope for increasing the present waterfowl populations in the Prairie Provinces, in fact we must find solutions to some problems of local overpopulation; but there should be hope for increased production in some areas of the East. All along the line we must fight impractical and nonessential drainage, to protect those breeding grounds we have; we must scrutinize all developments in land use to ensure that wildlife has its proper place in the multiple land use picture. We must take thought for the vagaries of the future, and plan for bad times as well as good, so that our waterfowl may have the opportunity to "bounce back" from depression. We must recognize our inter-dependence with our neighbours to the South, and we must reflect just consideration for them in our regulations and in our research and management.

I do not propose to dwell upon the provincial place in the team. We recognize, however, that provincial wildlife agencies deal with sportsmen, regulations, enforcement, and hunting licenses. Therefore they need waterfowl population statistics, kill statistics and management programs. It is proper that they should have a share in the surveys made to obtain data on which to base regulations, and in the banding and bag checking from which we derive kill statistics. In the light of the basic Canadian policy that management of resources is a provincial concern, I would suggest that land manipulation, a primary requirement of waterfowl management, might be considered a provincial responsibility.

Administration of the regulations for the control of crop damage was transferred to the provinces in 1953. It may be that further delegation of authority in waterfowl management may be desirable, to the extent permitted by the Migratory Birds Convention Act.

The Canadian Wildlife Service, as federal agent in the picture, is charged with over-all administration of the migratory bird laws, and is responsible for co-ordinating activities among Provinces and between Provinces and the United States. This responsibility is inherent in our Constitution, and is most beneficial when exercised in a sympathetic and democratic fashion. The Service also has a responsibility to the Provinces for undertaking those researches essential for adequate waterfowl management, by land manipulation and by regulation. International liaison is without doubt a federal function. Handling public relations and developing public understanding of wildlife policies will always be an important task.

In the light of the foregoing comments, then, what place in the team can the Canadian Wildlife Service best fill? Probably it is in research and planning, or to retain the football analogy, in coaching and quarterbacking. I noticed in a recent magazine where Mr. Jim Kimball, Director of Game and Fish for Minnesota, quoted an article explaining the numerous mergers of small and medium-sized companies into single great industries. It was stated that the reason for the mergers is not primarily to increase buying power and sales staffs, but rather to be able to afford the best research staff and facilities; if the companies cannot keep pace in research they will before long be out of business. We believe that the same applies to the big business of wildlife management, and specifically here in waterfowl management. We do not underestimate our needs in management; in fact these are essential to both present and future wildfowling, but our research must keep pace or we shall find ourselves always on the defensive.

Why is the research field so appropriate to the functions of the Canadian Wildlife Service? The major breeding grounds lie in Canada, and much of the future of wildfowling must rest with them. Research at best is difficult to sell to the public; when that research lies beyond local or national political boundaries it is difficult to argue in defense of it. Yet the results and the interpretation of research are not of merely local import, but are applicable nationally or universally. Thus a Canadian federal service, whose field force is constituted entirely of men trained in biology, zoology and wildlife management, appears to be admirably suited to conduct wildlife research in Canada. Conversely, since that group is small, it is inefficient to dissipate its energies in duties of management and survey which for the most part, beyond certain research phases, can be made routine. Some part of the research necessarily should be directed to improvement of survey, but a substantial portion should be aimed at the future, when the problems of waterfowl management may be expected to become painfully acute if not overpowering.

It is not proposed to deal here with types of research or relative priorities. These can be left to more detailed discussion around conference tables. But if we accept the thesis that more research is essential to the ultimate survival of the sport of wildfowling, we may ask what is implied by the division of labor I am suggesting. It would mean that the federal authority (in Canada) must be prepared to make regulations for seasons and bags on the basis of information provided almost exclusively by other agencies. To the Canadian Provinces, it could mean a heavier commitment in terms of money and men to assist in waterfowl surveys and management. To both the U. S. Fish and Wildlife Service and the individual states it could mean a slightly heavier commitment in terms of foreign travel for survey and banding. It would also mean acceptance of more Canadian research data, increasing as time goes on, for purposes of more intensive waterfowl management. (I should like to state here that all agencies should undertake some research, in order to have that cross-check of findings which is essential to healthy research.)

The division of duties as outlined leaves one major problem untouched—the providing of a refuge system in Canada that can swing into action, as required, to assist in maintaining waterfowl hunting for sportsmen throughout the continent. At the present time Ducks Unlimited (Canada) is the only agency active in the field of land manipulation for waterfowl. The problem is complicated by the present Canadian federal policy of remaining aloof from land management; by the relatively low human population density of our Provinces (especially the Prairie Provinces), which creates serious difficulties in the financing of projects; and by the fact that most of the hunters are south of the International Boundary. I shall not attempt to point up a solution here, since the problem involves legislative rights and responsibilities. But further development of public understanding and consequent effective legislative action must take place soon if the problem is to be squarely met.

In summary then, I would suggest that, because of present constitutional limitations and the basic philosophy relating thereto in Canada, the Canadian Wildlife Service can make its best contribution to the team in the backfield and in the clubhouse, by using its staff of wildlife biologists for applied and fundamental research directed towards present and future needs, and by helping to plan. Provincial wildlife agencies, which have the actual task of licensing and regulating hunting, will probably have to assist in carrying the burden of survey and land management. Canada as a whole, as custodian of the greater part of the continental waterfowl breeding grounds, has a responsibility to the sportsmen of the North American Continent extending beyond national or provincial boundaries.

My one direct association with football, back in collegiate days, is memorable for two reasons. For one thing, I played the entire game out as end, without any pads! More important, however, is the fact that we won the game overwhelmingly. We here are an international group playing against a big-name team we are wont to call Progress. Our task is to see that we have the team members, the know-how and the equipment to assure victory—we need lots of plans and pads. We cannot afford to take chances here, where we are playing a game for keeps. Victory means perpetuation of waterfowling, as we know it, at some reasonable level; defeat means at the least the end of public waterfowl hunting, and may mean no waterfowl hunting at all. My team did win that game handily back those many years ago, and my bruises were rather quickly recovered from. I do not mind a few bruises in a good cause, and I'm sure no one here does either, if we end up on the winning side. But let's play the game with the best of everything at our command; if we lose through lack of training, equipment, planning or teamwork, there will be no return match.

DISCUSSION

CHAIRMAN RUHL: I am sure that this is something that should provoke some discussion and, therefore, are there any questions?

MR. SETH GORDON [California]: I would just like to ask how this program of returning to the provinces the responsibility for the handling of the crop problem has worked out.

MR. MAIR: I would say that it has worked out excellently. We have had no problems whatsoever. We find that the provincial people are much closer to the problem, and thus they are more immediately aware of the problem.

CHAIRMAN RUHL: Are there further questions?

VICE-CHAIRMAN KIMBALL: I do not propose to jump up every time, but I do have one question that I would like to ask of Mr. Mair.

I notice that you said that you felt that one of your responsibilities was to prevent unnecessary draining in the provinces. We also have a big problem in the states, and we feel that we are losing the wetland areas through drainage at the rate of about 3 per cent per year. Could you tell us if drainage is really serious in the prairie provinces, in the duck producing area, and if so, is there anything that you can do about it?

MR. MAIR: I think that there are some people here who would be closer to the problem than I am. I think it is safe to say that it has not as yet become a major problem with us. I said that I felt that we had a responsibility to prevent this but I must confess that we have not found any way of preventing it as yet. We feel that it is just a laudable ambition on our part to prevent it.

THE STATES MUST HOLD THE LINE

E. B. CHAMBERLAIN, JR.

Chief of Game Management, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida

Twenty years ago, the appearance in a wildlife conference program of a title such as heads this paper would have caused some surprise. Today, it creates no excitement whatsoever, a fact not entirely due to public information concerning the author's talents. The situation reflects, rather, recognition and acceptance by all of us of the fact that continental waterfowl management must be a joint matter in which the states have an essential role. This point cannot be overemphasized, and I urge each of you to be constantly reminded of it. Undoubtedly, initiation of the Pittman-Robertson program had tremendous influence upon the states' participation in waterfowl management, just as it did in other fields. Also of great importance was the fact that as the states became more active in law enforcement, they found themselves dealing with regulations in whose formulation they had little voice. Simultaneously came the realization that the states have at least a moral obligation to share in management of this resource since during the time migratory waterfowl are within the boundaries of any state they are of practically the same status as nonmigratory game.

Although this is a new concept, few states would now care to totally wash their hands of waterfowl management. In order to better define the states' role, and to suggest the trend and substance of future activities, let us examine briefly the present situation. Today, the states are active in all phases of waterfowl management, though the individual programs may vary greatly, dependent upon local needs.

In waterfowl research, state work is now second to no other governmental agency. Carrying capacity studies, productivity studies, mortality studies, habitat management studies, harvest studies, and a host of other investigations are being carried out in sound, long range programs by state personnel who are as well trained, capable, and efficient as any comparable staff. Many activities are conducted jointly by the states and the appropriate U. S. and Canadian agencies. Population inventories, production studies, banding, migration and kill studies are of this nature. Certainly, without state participation such programs would lose much of their effectiveness.

In law enforcement, there can be little question that the bulk of the work falls to state personnel. Federal agents are invaluable, and ofttimes are the key to maintaining conditions of minimum violations. Their numbers are so limited, however, that inevitably it is the state enforcement officer who is met most frequently in the field.

Waterfowl development work, including acquisition, improvement, and management of habitat for refuges and shooting areas, was at first approached cautiously by the states but today is being carried out successfully on a large scale. The federal refuge system is outstanding, but is even now being approached in scope and value by state projects which usually include hunting as well as sanctuary features. Further, the major part of the continental waterfowl populations utilize lands other than those under federal control. It is the states that the owners or managers of these lands are most likely to contact, and it is the states who have greatest opportunity to influence the maintenance of such lands as waterfowl habitat.

Public education and distribution of information regarding waterfowl are largely carried out by the states. With present staffs and media, more people can be contacted through state programs than in any other way. It is gratifying to realize, too, that not only do the states possess the equipment necessary for worthwhile public information and education programs, but have the trained, competent personnel required.

Formation of the Flyway Councils was a milestone for the states in waterfowl management. Through the Councils, programs in the various states could be effectively integrated, common objectives could be defined, standard procedures adopted, and research findings could be readily circulated. For the first time it was possible for the states to work effectively with the Fish and Wildlife Service in determining regulations. Considerable improvement has been made in the mechanics of handling the adoption and promulgation of these regulations. Perhaps most important, formation of and participation in the Councils by the states, and recognition and acceptance of the Councils by the Fish and Wildlife Service, clearly establishes the states as participants in continental waterfowl management.

I submit, however, that from now on the states will not merely be participants, but will assume a leading role. The means for taking this position is at hand—properly functioning Flyway Councils. It is up to the states to take the step and with it the accompanying responsibilities. As in all other fields, such a position of trust and duty involves acceptance and execution of complex responsibilities. If the states are to be true equals and leaders with the Federal and Canadian agencies on a waterfowl management team, what is expected of them, what do we really mean when we say the states must hold the line?

First, an attitude or philosophy of unselfish, realistic waterfowl management must be achieved. In most cases this has already been reached, and each individual state realizes that successful management depends on the subordination of local interests to the good of the whole. With this attitude is an accompanying realization of the need for sound technical findings and the application thereof.

It is essential that the states continue and intensify the various research programs now underway. Recently, state research has been of a quality equal to any on the continent. It is expected that state employees will continue to work in a climate favorable to productive research, and even more than in the past state investigations will serve in conjunction with and as a check on similar federal activities. We can no longer be content with opinions passed down from some Olympian height.

In the future, acquisition, development, and maintenance of waterfowl management areas and the preservation of waterfowl habitat in general will become increasingly a state function. This will be done not only directly by state game agencies, but through the efforts of these agencies in working with the Corps of Engineers, private land owners, and public agencies concerned with land and water management. As an example, let me cite the program of Florida's Central and Southern Flood Control District. This agency was created in 1949 to carry out the state's obligations in working with the Corps of Engineers to provide water conservation for one-fourth of the state's area at an estimated cost of 280 million dollars. The District early showed an awareness of wildlife values. Already, two water conservation areas totaling 725,300 acres have been made available to the State Game Commission for operation and a similar area of 142,000 acres licensed to the U. S. Fish and Wildlife Service. Perhaps even more important is the great consideration given by the District in all of its planning to wildlife values, thanks to the high degree of cooperation and cordial working relationships that have been achieved. As a result, waterfowl will fare well in thousands of acres of central and southern Florida wetlands.

With private land owners, the trend is more and more toward seeking state help in wetland management. It is most regrettable that we have on the other hand those land owners and hunters who wish only to exploit the resource or to destroy waterfowl habitat. Because of such factors, state programs will necessarily remain realistic and thus will tend to moderate parallel Federal programs. The net result will be that the states, either directly or through contact with various classes of land owners, will influence or control the status of the majority of the waterfowl habitat in the United States.

In public relations and education, state programs will doubtless be enlarged. Even now, more people can be reached through state agencies than by other channels. The scope and effectiveness of such state work will increase. Likewise, state law enforcement will improve. In all cases, states are paying more attention to the calibre and training of their personnel. Even more important, the states will in the future more clearly recognize the necessity for improved and increased public relations and enforcement work.

In summary, it may be said that while recognition of the states as participants in waterfowl management is relatively new, state activity is now of a high order. The states should, however, assume a leading role rather than continue as mere participants. This contention is supported by the status of state programs of research, by the status of state development and maintenance programs, and by state law enforcement and public education works. The greatest reason, however, lies in the desire and need for the states to carry a fair load with consistent responsibilities for continental waterfowl management.

PUBLIC SUPPORTERS IN THE BACKFIELD

ROBERT WINTHROP
President, Ducks Unlimited, Incorporated, New York City, New York

Public support is as necessary to success in the efforts to conserve our natural resources as a good backfield is to a winning football team.

To get the best results from Public Support we should know: 1) What is Public Support? 2) How can Public Support be enlisted? 3) What can it do? and 4) What has it done?

Webster's dictionary defines the word "Public" as the general body of mankind or of a nation, state or community. It defines "Support" as the act of supporting or sustaining.

Natural resources are the fundamental source of the wealth of nations, and the use that is made of them is therefore of vital interest to the public. The conservation of natural resources is not the responsibility of special groups or interests, but of *all the people*.

HOW CAN PUBLIC SUPPORT BE ENLISTED?

Abraham Lincoln, who probably had as much need for public support as anyone in history, once said:

> "When the conduct of men is designed to be influenced, persuasion, kind, unassuming persuasion, should ever be adopted.
>
> "It is an old and true maxim that a drop of honey catches more flies than a gallon of gall. So with men. If you would win a man to your cause, first convince him that you are his sincere friend. Therein is the drop of honey that catches his heart which, say what he will, when once gained, you will find but little trouble convincing his judgment of the justice of your cause, if indeed that cause really be a just one.
>
> "On the contrary, assume to dictate to his judgment or to command his action, or to mark him as one to be despised, and he will retreat within himself, close all the avenues to his head and heart; and though your cause be naked truth itself, and though you throw it with more than Herculean force and precision, you will no more be able to pierce him than to penetrate the hard shell of a tortoise with a rye straw.
>
> "Such is man, and so must he be understood by those who would lead him, even to his own best interests."

That quotation contains as much information on public and human relations and how to gain public support as might be found in volumes and volumes of material on the subject.

It cannot be denied that self-interest creates the strongest urge to action on the part of an individual. In the case of a duck hunter, for instance, his interest will be more ducks and an ssurance that the supply will be maintained and increased. The same can be said of all individuals interested in particular pursuits as a livelihood, hobby, vocation or avocation.

The mind of man refuses to pay heed or give thought to anything in which he is not interested. If you wish to capture a man's mind, you must first of all get his attention, and you cannot do this unless you arouse his interest. He must be made to feel that the message is of personal concern to him—one of great importance to his welfare—something that he cannot afford to miss. He is more interested in himself than in anyone else. Hence, the appeal to his self-interest. If he has had experience, you cannot capture him with commonplace phrases. We can write all we want to, but the problem is to get people to read and believe. This will lead to the desired action.

Recently a well known writer approached the managing editor of a leading general circulation magazine, with a request for an assignment to do a story on waterfowl conservation. The managing editor stated that he knew nothing about waterfowl or the problems involved in their survival, but if the writer submitted a story that he, the managing editor, could start and finish without losing interest, the story would be printed.

This is a concrete example of what the presentation of any problem should be. I might add that the story was accepted and printed.

To reach the public, every tool of communication—newspapers, magazines, radio and TV—should be utilized to present and distribute the facts. This means that every effort must be made to cultivate and enlighten the people engaged in these activities and make them an important part of the backfield.

Oftentimes it may be necessary to repeat the same story, over and over again in order that it may obtain the greatest coverage possible. Most of our rod and gun writers and the sports editors of newspapers, magazines, radio and television stations are deluged with material with little or no reader or listener interest. Stories should be presented in a manner that is appealing not only to the editors but to those to whom they direct their communications. Fortunately for conservation, the vast majority of our rod and gun editors are taking a very active part in the preservation of our natural resources, and through these reports we can expect greater interest from the public who will make up our backfield.

WHAT CAN PUBLIC SUPPORT DO?

Public Support can be the deciding factor in the success or failure of a worthwhile cause.

The problems that continually face conservationists require the talents not only of scientists, but of people in every field, in order that we may arrive at a common language and understanding. For instance, engineers might look on a problem differently than biologists. If a dam is to be constructed, it is the engineers' duty to locate and design it so that it will serve its primary purpose at the lowest possible cost. A biologist or naturalist might view the area and see an opportunity to obtain great benefits to natural resources that would more than offset the necessary additional costs of a different location or design. Both are equally honest in their conception of the job as they see it, but to get agreement and the most beneficial results, each must be made to see and understand the ideas and objectives of the other.

People trained in other specialties likewise may have different views and these must be recognized and carefully weighed so that they too may be incorporated into the final decision. This teamwork, developed and properly guided, can be meshed into a combination of various skills working effectively together for a common cause and idea.

An enlightened Public, not too closely involved in the pros and cons of any particular problem can view a situation objectively and remain cool, thoughtful and discriminating, and thereby apply wisdom to the solution of the many problems that always have and always will arise when diversified interests are involved. It will also provide the long-range thinking that is a paramount need in all matters affecting the utilization and preservation of our natural resources.

Public Support can also include the guidance of older and mature generations that are in a position to give the benefit of their long experience and observation in living.

WHAT HAS IT DONE?

As a practical example of the application of team work by the backfield, I would like to cite some of the work of Ducks Unlimited because I know it best. During the eighteen years of operation we have been faced with many of the problems that enter into all efforts concerned with conservation; of which financing is not the least important. The Board of Trustees, numbering 60 individuals, all interested in conservation generally, and water and waterfowl in particular, represents leaders in industry, the sciences, and professions from all sections of our nation. They are part of the backfield responsible for the policies of the organization and the direction of the numerous state and local committee chairmen and their committees, who are charged with the responsibility of obtaining the funds so necessary to do the work. These Committeemen also represent industry, science and the professions, and are another excellent example of what public support means.

In addition to the solution of the always present financial problem, let me quote from a report of the Policy Committee of Ducks Unlimited, a few of the recommendations made to Trustees, State Committeemen and members of Ducks Unlimited, to be followed by them, as individuals in their respective localities:

1. Oppose ill-conceived drainage or flood control projects at local level.
2. Accept, as individuals, full share of the responsibility for protecting our remaining natural water resources and opposing all unjustified drainage and pollution.
3. Encourage the establishment of local refuges.
4. Alert our organization as quickly as we hear of drainage or flood control in the discussion stage. (Such information to be passed on to other agencies that can take suitable action.)
5. Whenever DU meetings are held urge our members to become self-appointed guardians of our remaining marshes and to promptly call to the attention of local groups—gun clubs, duck clubs, sportsmen's clubs and conservation organizations to any harmful plans.
6. Give audience to representatives of government and other organizations subscribing to the objective of more and better duck wintering areas.

The problems arising in our field operation in Canada also require a good backfield of public supporters. Ducks Unlimited (Canada) is governed by an International Board of 30 Directors—fifteen each from Canada and the United States—again, representatives of various fields of endeavor in both countries.

The success achieved in the Canadian operations has been largely due to the cooperative attitude that has been obtained with the help of this backfield.

I would like to mention a few practical examples of projects that succeeded mainly through the support and cooperation of governmental and private agencies, and individuals in Canada. These included the Dominion Government Conservation Department, the Water Stabilization Committees of the Provincial Governments of Alberta and Saskatchewan; the Department of Natural Resources of Manitoba; the Dominion Government Department of Indian Affairs; local governments; the Canadian Utilities Power Company (a subsidiary of the International Power Company of America); and the farmers and citizens of Western Canada who have contributed generously without charge thousands of acres of land to conservation.

Among the most recent projects completed by DU through this combined cooperation of Canadian agencies, is the massive Hay Lakes Project located 600 air miles northwest of Edmonton, Alberta, and covering a flooded area in excess of 80,000 acres Here was an area that nature had apparently abandoned. Constant erosion of tributary streams caused this once flourishing breeding ground for millions of ducks and geese to become nothing more than a very shallow basin which not only failed to provide the necessary water for wildfowl, but resulted in the elimination of a valuable colony of muskrats and other furred animals that were an important source of income for the Slave Indians of that area. Oddly enough, the source of the water supply remained constant: two rivers furnishing abundant water in the spring which was lost due to erosion. Friends of Ducks Unlimited who remembered the area in its prime, felt confident if Ducks Unlimited would make a study of the area, means could be found to restore Hay Lakes to its original value for wildlife and waterfowl. A survey was made in cooperation with the Government of Alberta and, with the approval of the Dominion Department of Indian Affairs, work was started in 1953 and completed in 1954. The Alberta Government has reserved all affected lands in order to preserve the area for conservation. The Department of Indian affairs is vitally interested in extending this project and has already set aside money for future dam construction. It should also be mentioned that the Indian Affairs Department has completed an inspection of the area and reported that the muskrat catch has increased considerably since the reflooding of the lakes. I personally visited the area last September and saw myriads of waterfowl that were not there the year before.

The Vermillion Project 120 miles east of Edmonton, with a shoreline of 10½ miles and a water area of 660 acres might well typify the results which can be accomplished by Government, private business and private conservation agencies working together. Built in 1952 through the joint cooperation of the Alberta Government, the Town of Vermillion, Canadian Utilities, Ltd., and Ducks Unlimited, it provides electrical power for the residents of the community, recreational facilities for the surrounding towns, and a sanctuary for wildlife. DU made the surveys and contributed equipment to build the dam; the Provincial Government provided construction supervision, material and funds; the Canadian Utilities Company provided additional funds and took care of the land agreements and the Town of Vermillion now takes care of the maintenance of the completed work.

Many more, in fact all of the more than 400 projects completed by Ducks Unlimited have required assistance and action from the public in the backfield. Often the influence of the backfield had to be exerted for a number of years before any work could be started.

No agency, government or private, including Ducks Unlimited, will be better than the number and power of the people interested in the purpose and work of that Agency. When an organization loses touch with the people who started it and who are still interested in its original purpose it will very likely begin to fight not for the people or cause for which it was established but for itself. There is only one antidote for such a condition—a strong well-informed Public.

As this paper was being prepared I was reminded of one of Ed Howe's aphorisms. The Sage of Potato Hill, as he was known, once said: "Nature never once produced a creature, without providing for its needs. Man's greatest fault has always been too much preaching and not enough work."

Properly informed a good hardworking Public instructed and guided by the sincere and hardworking agencies that are responsible for the conservation of our Natural Resources can accomplish results that will make our country a better place in which to live, not only for us today, but also for those who come after us.

DISCUSSION

CHAIRMAN RUHL: Now, I am sure that there are some questions that you might wish to address to this speaker.

DR. GOVE HAMBIDGE [Washington]: I would like to ask him where he got that extraordinary quotation from Lincoln.

MR. WINTHROP: I would like to say that I have an excellent staff in my organization and they supplied me with it.

MR. ERNEST PAINTER [Canada]: I would like to pay Ducks Unlimited a compliment for the splendid work they are doing in our provinces. A while ago it was asked whether or not we had much loss of these wetlands. In fact, we have been too darn wet for several years but then we are keeping our eye on those places where we may have to put in a plug. I think that we certainly have got to watch the line and see to it that we do not lose our permanent marshes.

GAINS AND LOSSES IN THE WATERFOWL GAME

J. CLARK SALYER II[1]

Chief, Branch of Wildlife Refuges, U. S. Fish and Wildlife Service, Washington, D. C.

The Number One problem of North American waterfowl management is, and continues to be, the accelerated loss of basic waterfowl habitat—marshes, sloughs, overflow lands, swamps, and all the other types of aquatic waterfowl habitat. We are making wonderful progress in better breeding ground surveys and winter inventories; our regulations are getting more flexible and realistic; we are making steady progress against waterfowl diseases; but, as yet, no one has come up with a very effective method of preserving the wetlands used by our continental waterfowl resource.

At the beginning of a revived waterfowl management program for this continent that he launched in 1934, "Ding" Darling, the famous cartoonist and outstanding conservationist, was truly prophetic when he remarked:

> "The beginning of wisdom in the field of game management seems to come only with the threat of total extinction. I am not sure that first among the items of progress should not be mentioned the gradual permeation of this wisdom into the consciousness of the majority of sportsmen. More and more sportsmen have learned through experience that game management is their only salvation."

"Ding" might well have addressed that remark to the rank and file of all professional conservationists.

DESTRUCTION OF HABITAT

Today waterfowl habitat is decreasing a hundred times faster than we are able to restore it. The pothole country of the United States proper and Canada produces 70 per cent of the game ducks on the continent. The portion of this area lying within the United States produces between 10 per cent and 15 per cent of North America's game ducks. Agricultural drainage has taken potholes at the rate of 50,000 acres per year. Mind you, this is prime nesting territory, as good as any that Canada exhibits. In other words, we are losing prime waterfowl breeding habitat equal to the three national refuges in the Souris loop of refuges every year and have been doing so for the past 15 years. Canadian farmers in the pothole area are just beginning to drain potholes; but it seems inevitable, as has been experienced in the United States, that such pothole drainage in Canada will increase as the years go by. This drainage threat is heartbreaking

[1]In the absence of the author, this paper was read by Mr. Richard Griffith.

because we can never hope to restore production areas at the rate we are losing them. Perhaps we should concentrate more effort on saving the northern wetlands today than we are, since they are our first line of defense, being breeding grounds, yet withal the most vulnerable portion of our waterfowl habitat. Wintering grounds and intermediate flyway areas are all under continuous assault by the ever-increasing pressure of agricultural and industrial needs, flood control, harbor improvement, intracoastal waterways, and manufacturing waste disposal—all so endearing to the exponents of big business and the already disproven theory that the world is starving for lack of adequate agricultural products! Witness our Gargantuan and indisposable stockpile of food and fiber products that now bows the shoulders of our Nation's economy.

Two of the strangest, but most virulent, demands for marshlands these days are for disposal dumps from modern industry, such as ash dumps from large powerplants, and the use of surrounding marshlands in many towns in the northeastern United States for the sites of low-cost housing. Both of these are greater threats than you might imagine and are very acute in the New England States, New York, New Jersey, Delaware, Michigan, and Iowa, just to mention a few states in which the problem is rampant.

The present worry in Washington over surplus crops may mark the end of the pendulum's swing toward agricultural drainage. A good part of this surplus has been brought about by accelerated drainage of waterfowl habitat, sponsored and subsidized by the Government. Conservation authorities generally were intrigued and optimistic that the proposed "soil bank" program would lead to the recovery of an appreciable part of the former waterfowl marshlands. However, so far in the preliminary reports about this program, there is nothing encouraging. In fact, there is a new and devastating threat in the innocent proposals found in five bills so far introduced in the Congress to prohibit farming and grazing of any federally owned lands. The proponents of these bills tell us that they are shooting for control of crop production on the vast acreage of military held lands. Among these lands are alleged to be 8 per cent of the Nation's croplands. However, these bills as now drawn would prevent the farming of refuge croplands, without which the present level of waterfowl numbers cannot be maintained. Almost half of our Nation's waterfowl population now finds its food on the Service-farmed croplands at some time of the year. Practically all of our Canada goose populations are centered around the larger federal and state refuges, where cropping is a routine refuge activity. In fact, here in the Service we say that our "three R's" of waterfowl management are Research, Regulations, and Refuges—by the latter meaning intensive development, including 100,000 acres of crop production for annual consumption by the Nation's waterfowl.

Thus, if the farming of Service waterfowl lands is prohibited, many of our most spectacular refuges might as well be boarded up for all the good that they will do the waterfowl resource, and the effects will be in startling evidence in a year's time. We shall have lost a large part of the waterfowl population gains made in the past 22 years.

I can see no wholesale solution for this troublesome situation. The pressure of our growing population in the 10 years after World War II indicates no rosy path in future waterfowl management. There are some new developments, however, that will permit a more realistic attack on the problem as we go ahead, which I shall refer to later in this paper.

MOSQUITO CONTROL VS. WATERFOWL MANAGEMENT

Paralleling the agricultural and industrial attack upon waterfowl habitat is the large-scale revival of mosquito control drainage. A number of bills are in the Congress this session to aid the states in such activities. The revival of this type of drainage will repeat the large-scale mosquito control drainage of the depression years, from which the Atlantic flyway has yet to recover, the only difference being that in the future all four waterfowl flyways will feel the effects of this obliterating blight. Thus, I am giving this subject more discussion than the limited space of this paper easily affords.

Mosquito-control programs often cause serious conflict with waterfowl management objectives. Back in the depression days of the 1930's, thousands of acres of coastal marsh were needlessly destroyed through ill-advised ditching. Such drainage frequently lowered the water table, causing ponds to dry up and producing unfavorable changes in marsh vegetation and marked reductions in the invertebrates that serve as food for waterfowl.

After a long, bitter struggle, federal support for this work was withdrawn. Little was done in this field during the war years. At the close of World War II, however, the use of DDT came to the fore. The glowing reports on the performance of this "wonder" chemical captured the public fancy, and it and other insecticides were proclaimed a panacea for abatement of nuisance mosquitoes. While less detrimental than ditching to waterfowl, these chemicals proved harmful in some instances to fish, shellfish, and many aquatic invertebrates. Control with DDT and some of the other new insecticides generally did not cause conspicuous losses of birds, but the continued use of these stable materials reduced the numbers of food organisms and undoubtedly lowered the value of certain areas for waterfowl.

The appearance within the last few years of strains of mosquitoes resistant to many of the new insecticides has again caused the pendulum to swing back to permanent types of control involving alteration of environmental conditions to reduce the mosquito breeding potential. In 1953 the Florida Legislature passed a bill allocating $1½ million annually for permanent control of mosquitoes and biting flies; this is in addition to the appropriations of the various abatement districts within the state. In California some $3 million is spent yearly on control of mosquitoes, with the emphasis on source reduction. This same philosophy is gaining precedence in other quarters. Unfortunately, most entomologists still think largely in terms of drainage, such practices as filling or diking, and dewatering, that completely destroy the value of marshlands for waterfowl. It is conceivable that such programs, if not modified, could in a few years nullify all recent gains in improvement of our rapidly dwindling waterfowl habitat. Several bills have been introduced in the 84th Congress that would make as much as $3 million per year available to the Public Health Service and the Department of Agriculture to carry out a program of research and technical assistance to the states and local communities for control of mosquitoes. As written, no provision is made in the bills for integrating mosquito-control measures with preservation of waterfowl habitat. Thus, the opportunity for repetition of damage that occurred to marshes under federally subsidized C.C.C. and W.P.A. ditching programs is obvious.

In view of the increasing trend toward permanent control of mosquitoes, there is a definite need for development of alternative methods more compatible with wildlife management. The Fish and Wildlife Service and a few of the states have recognized this need and in recent years have undertaken studies in cooperation with mosquito abatement agencies. Preliminary findings of investigations in Delaware and New Jersey have revealed that, contrary to general belief, impounding of water can effectively reduce mosquito nuisance provided units are properly constructed, operated, and maintained. Other promising techniques include deepening of mosquito breeding holes and construction of modified forms of ditching that drain surface water but do not appreciably lower the marsh water table. Further research and demonstration of these and other procedures that offer promise of integrating the objectives of mosquito control and marsh management for waterfowl are our chief hopes for resolving conflicts in these broad fields of public concern.

WATERFOWL DISEASE

The waterfowl manager views the disease picture with one thought uppermost: "How can we manage waterfowl or their habitat so as to reduce mortality from disease?" Consequently, despite the large number of pathogenic organisms that have been described and that might play important roles locally, the manager ordinarily is concerned with a relatively small number of disease problems. Some of the most significant mortality factors are as yet beyond his control.

Botulism still remains the Number One disease on the list for North American waterfowl. However, despite the occasional severe outbreaks that continue to plague us, we have learned much about controlling widespread losses from this cause on those areas where we have adequate water supplies and proper structures for managing available water. We know, for example, that control over water distribution is fundamental; that we must avoid and prevent reflooding mud flats in late summer in most western areas; and that some areas, with our present knowledge, are best left dry during the botulism season to avoid severe waterfowl losses. Research on this important disease problem is continuing and may yet give us more positive preventive measures that will reduce losses still further.

A second problem that often becomes severe is that of avian cholera. Here the waterfowl manager usually is at a loss, since the evidence seems to indicate faulty environment or poor sanitation in areas not under his control as the chief contributing agents. Improper disposal of slaughterhouse offal and careless disposition of carcasses of domestic fowl that have died from the disease have been suspected as causes of some severe outbreaks of cholera.

Lead poisoning is a continuing and aggravating threat to waterfowl. Research has been unsuccessful in developing satisfactory substitutes for lead. Until this is accomplished, there are few, if any, positive measures that can be taken by the waterfowl manager to combat this mortality factor.

Closely related to disease in its broadest aspect is the problem of pollution. Oil, industrial, and mining wastes in many of our rivers and coastal bays continue to cause spectacular waterfowl losses. Progress in solving our pollution problem is moving along at a snail's pace.

The waterfowl manager views research on diseases with considerable hope. He may be impatient with results that seem to add up to a mere listing of pathogens, but it is a fact that we are still in a pioneer stage of trying to find the causative agent or agents of waterfowl losses that periodically flare up in the field. Until the specific cause of these die-offs has been determined, there is little that can be done to prevent them.

ENFORCEMENT OF CONSERVATION LAWS

It is refreshing to report distinct gains in the enforcement of our waterfowl conservation laws and in the cooperation between the States and the Service in this respect. The states, with but one or two exceptions, cooperate fully in providing protection to waterfowl. Of particular interest is the action taken in respect to the enforcement of the baiting regulation by Mr. Hayden Olds, newly appointed Chief of the Ohio Division of Wildlife. Shortly after taking office and just prior to the waterfowl season, Mr. Olds announced through the press that Ohio's waterfowl hunting regulations were similar to those issued by the Department of the Interior and that Ohio game law enforcement personnel had been instructed to enforce them without fear or favor. The number of incidents involving baiting dropped to 25 per cent of that of the previous year, and apprehensions dropped in proportion. Magistrates of the state courts levied substantial fines in cases brought to their attention, with the result that there was a marked disinterest in engaging in the practice of baiting throughout the entire season.

The enforcement of the anti-baiting regulation in California has been most significant. The combined state and federal forces processed two cases in the 1953-54 season, 21 cases more in the 1954-55 season, and the tempo of enforcement swelled to 49 cases in the 1955-56 season.

Another outstanding example of cooperative state and federal game-law enforcement concerns the breaking up of a large organization that was engaged in the illicit sale of waterfowl in the vicinity of Reelfoot Lake, Tennessee. Fifty individuals were apprehended as a result of this painstaking and perfectly executed undercover operation financed by state and federal funds and carried out by state and federal personnel. The results of this important case have a far-reaching significance, for the breaking of the market hunting ring benefited not only the sportsmen of Tennessee, but also duck hunters throughout the entire Mississippi flyway as well.

CAPITAL INVENTORY OF THE RESOURCE

By reason of the migratory bird treaties, the Governments of Canada, United States, and Mexico are held responsible for the preservation of migratory waterfowl, and the act that implements the treaties in the United States includes the following directive: "To determine when, to what extent, if at all, and by what means it is compatible with the terms of the conventions to allow hunting." The Fish and Wildlife Service is the agency within the U. S. Government responsible for carrying out the provisions of this act.

To meet the above requirements for sound management data, the

Service has greatly extended its field operations in recent years to gather first-hand, accurate data on (1) the production on the breeding grounds each year and (2) the midwinter inventory of the continental waterfowl population. A heartening aspect of this situation is the great participation of the States in this revitalized program in recent years. Canada is increasing its ever-present cooperation in this respect. The net results are more accurate data secured by greater coverage of ground and increased efficiency in operating methods which have resulted in standardized procedures that tend to stabilize the comparative accuracy of the operations from year to year. The end result is that we have better information at an earlier date than we have ever had in the past on the facts surrounding our ever-fluctuating waterfowl population. This has made possible more realistic and flexible waterfowl hunting regulations.

INCREASING WATERFOWL PRODUCTIVITY OF MARSHES

The Service and the states are making strides in controlling and changing waterfowl habitat in the interest of greater carrying capacity. The only manner in which the Service has been able to keep up with the rapid loss of waterfowl habitat is by pyramiding waterfowl populations on existing federally controlled lands. We have found that by modern soil management methods, we have increased our crop production ten times and our waterfowl carrying capacity nine times. It is thus that we have been able to quadruple the Canada goose population in the Mississippi flyway in the last 20 years.

So long as we had plenty of acres of marshland to support our nation's waterfowl population, there was little need for intensive marsh management. Times have changed, however. Now that drainage has dried up a large share of the natural habitat, it is essential that the remnant of wetlands be made as productive as possible in food and cover for waterfowl.

This is easier said than done, since marsh-management money does not go far when prorated on a per-acre basis. However, some encouraging progress is being made in finding practical ways to improve marsh vegetation. Management of water is still our most important tool for this purpose, but production of cultivated crops, plus mowing and burning, is also valuable in improving wetland food and cover supplies. The newest tool, and one of the most promising, is the use of herbicides. Chemicals have not proved to be a cure-all for marsh problems by any means, but they are helping a lot. They have been useful in controlling waterhyacinths, cattails, lotus, and other unwanted species on many thousands of acres; and as promising new herbicides such as Dalapon come along, it appears probable that they will play an increasingly important part in future management of waterfowl habitat. To this end, State and private organizations, as well as several Federal agencies, deserve credit for patient testing of new and potentially better herbicidal methods of controlling marsh weeds.

Perhaps the most sunny spot in the waterfowl management picture today is the goose situation. To maintain your morale after my views on pothole drainage, this should be elaborated. The vast area of northern Canada and Alaska which produces most of the continental goose population is apparently, at least in the foreseeable future, in no danger of the type of exploitation by man which has been so ruinous to waterfowl habitat farther south. Since this is true, if we are able to protect enough basic broodstock to send back to the breeding area each spring, we should be able to stay on top of the goose management program.

In the past our geese on their wintering grounds have been too concentrated in a few hellholes of commercial exploitation. The institution of a number of large federal and state refuge or management areas has dispersed these concentrations, and with the attendant build-up through the saving of birds of the year at these new sites, we have some 18 new major flocks of Canada geese, most of which have increased to such a saturation point that public hunting is possible and necessary. This has made possible the goose hunting opportunities for more sportsmen. In fact, it is now apparent that any state may have one or more major goose flocks with satisfactory hunting by the exercise of the few basic principles of goose management that have been devised in the last 20 years if the state is willing to buy the necessary land and to do the necessary cropping and other intensive management features required.

Along with this restoration success, the problem of giving all duck stamp purchasers equitable opportunity to utilize the waterfowl resource is serious and is badly neglected in some areas. Public funds, both state and federal, are being used to manage areas that are supporting shooting for small private interest groups and ignoring the rights of the average sportsman. In the past year no less than six major corporations have purchased large acreages of prime marshland for the exclusive use of their employees. Both state and federal waterfowl managers should give this problem more attention.

STATE CONTRIBUTIONS TO WATERFOWL RESTORATION AND MANAGEMENT

Our hat is off to the zeal and enthusiasm with which the states are prosecuting their waterfowl restoration work. This is indeed an encouraging facet of the over-all waterfowl management program.

Only a few states, California and Utah in particular, had acquired or developed any lands for waterfowl prior to the enactment of the Pittman-Robertson Federal Aid in Wildlife Restoration Act in 1937. In the intervening years, all 48 states have invested some part of these funds in waterfowl restoration and management. Through June 30, 1955, they collectively acquired 483,919 acres of land costing $13,496,-280 for ducks and geese. In the same period, they invested $18,706,277 in the development, operation, and maintenance of 1,415,923 acres in waterfowl management areas. With research expenditures of $5,-576,616 added, the Pittman-Robertson cash outlay for waterfowl work in the 48 States totals $37,779,173 ($9,444,793 State and $28,334,380 Federal). This represents nearly 30 per cent of total obligations since the beginning of the program.

During fiscal year 1955, the states submitted waterfowl projects calling for the expenditure of $6,859,287, or 39 per cent of total program obligations. Assuming that income from the excise tax on sporting arms and ammunitions remains fairly constant and that the $13½-million backlog becomes available in five equal installments, as authorized by the Congress, state expenditures for waterfowl may run as high as $8 million during each of the next several years.

Examples of accomplishments are many. The first Pittman-Robertson project to be approved in July 1938 was to finance development on Utah's Ogden Bay Waterfowl Project. The largest Pittman-Robertson acquisition and development for waterfowl is Minnesota's recently completed 54,000-acre Roseau Waterfowl Management Unit. With participation at an average of about 60 per cent state money and 40 per cent Pittman-Robertson funds, Minnesota has acquired 156 drainable marshes totaling 13,140 acres. Kansas has just finished construction of two impoundments with an area of 1,038 acres on the Marais des Cygne Waterfowl Area and is now working on the diversion of Arkansas River water into the previously completed 20,-000-acre Cheyenne Bottoms. The 12,500-acre Sauvie Island Game Management Area in Oregon was acquired and developed with Federal Aid assistance. With 6,600 acres in refuge and 5,900 acres open to hunting, this area furnished nearly 10,000 hunter man-days of sport in the 1954 season. Other recipients of Pittman-Robertson financial attention include such areas as Oregon's 14,000-acre Summer Lake, Arkansas' 37,000-acre Bayou Meto, New Jersey's 13,000-acre Tuckahoe, and Idaho's 11,000-acre North Lake.

At the other end of the scale from the size standpoint are the small marsh developments in several eastern states. New York, the pioneer in this type of development, has completed 650 of these duck production units averaging about 4 acres in size. Trapping and banding work have disclosed that these newly created small marshes are producing five ducks per acre per year. Iowa has accorded major emphasis to waterfowl restoration by investing nearly 70 per cent of its Pittman-Robertson income to date in acquisitions and developments for ducks and geese. Georgia has initiated developments on the recently acquired 8,500 acre Altamaha Waterfowl Management Area. One hundred miles to the north, South Carolina has completed a major part of the dikes and marsh reclaiming job on the 7,000-acre Bear Island Waterfowl Area. Restoration work, on a cooperative basis by the State of Missouri and the Fish and Wildlife Service, has resulted in the development of the Duck Creek Wildlife Management Area. It lies adjacent to the Service's Mingo National Wildlife Refuge, covers nearly 6,000 acres, and is divided into four major parts.

Waterfowl research has been carried out in at least 44 states, Alaska, Hawaii, and Puerto Rico with Federal Aid funds, and last year 38 states, Alaska, and Hawaii continued these investigations. Appraisals of the success of waterfowl development are important as guidelines for future activities. For example, a study of California's waterfowl acquisition and development program showed that 32,601 hunters harvested 81,054 birds, for an average of 2.5 birds per nimrod, on the State's developed areas during the 1954-55 season. A large share of the census figures on waterfowl breeding success and kill figures throughout the country is gathered and compiled by Federal Aid biologists. During the years 1953 and 1954 approximately 339,000 waterfowl have been banded on the North American Continent. Somewhere between 80 per cent and 90 per cent of that number were banded by Federal Aid personnel. There is no doubt about it—the states, with the help of Pittman-Robertson funds, are making major contributions to the restoration and better management of ducks and geese. Without that splendid help on all facets of the problem, the plight of waterfowl would be much more serious than it is today.

Before leaving this field, the fine contribution of Ducks Unlimited should be recorded. Ducks Unlimited has gone through its initial labor pains which gave birth to its fine program and is now entered upon a period of intensive management of its waterfowl holdings which is inevitably leading to greater production. This is a real contribution to the over-all increase of our best game ducks and geese.

River Basin Studies

You are aware probably that this branch of the Fish and Wildlife Service was created to review the many water impoundments and manipulations of our Nation's streams and lakes by various construction agencies of the Federal Government, the idea being under the

Coordination Act to strive not only to minimize damage to our wildlife resources, but also, in the course of such gigantic operations, to see if new wildlife values could be achieved. This program, with ever-increasing momentum, has a lot to its credit in the way of saving of prime waterfowl areas and minimizing acute losses. One of its finest contributions has been an objective survey of the nation's wetlands of fundamental importance in the maintaining of our waterfowl resource. This survey, more than any other factor, has served to reveal where the main gaps exist in our program of preserving waterfowl lands of first importance. It has moved in aggressively upon the pothole drainage program and has served to dramatize the dangers to our waterfowl contained therein. As a result, we have seen statewide apprehension and corrective activity leading to, if not full control, at least a turn in the downward and destructive trend of our Nation's wetlands. The governors of several states now aware of the situation have called statewide conferences. A number of states, such as Iowa, Minnesota, and California, have made the halting of waterfowl habitat drainage one of their main conservation objectives. These programs are getting results.

This has resulted further in the Arkansas and Tennessee Game and Fish Commissions saving large acreages of waterfowl habitat in their states and, better yet, in getting basinwide consideration of the waterfowl problems in their principal river valleys. The saving of waterfowl acreages in these two states alone has been well over 110,000 acres.

Not the least of the achievements here is the signing of a memorandum of understanding on May 12, 1955, with the Soil Conservation Service in connection with works of improvement carried out under the Watershed Protection and Flood Prevention Act of August 4, 1954 (P. L. 566). To date some 51 reports have been submitted either to State conservation departments or direct to the Department of Agriculture for planning or final work plans under this act.

Tied in with the over-all River Basin program is a new drive on the part of the Service, in cooperation with the states, to save every possible acre of waterfowl lands. From time to time small acreages of suitable waterfowl lands—5, 10, 50, 150 acres—of federal lands appears as surplus to the needs of a particular agency. The Service has set up a program to ferret out such opportunities and to arrange for their proper management by the Service if they are large enough, by the states if they are interested, and by many responsible sportsmen's clubs, Audubon chapters, and other conservation groups. The accumulative effect of this program will be significant before many years have passed.

CONCLUSION

Finally, the most favorable trend that I can discover these days is a greater awareness throughout our general population of the values of our waterfowl resource and the practical measures necessary to keep it whole. We should realize that only 10 per cent of our total population which treasure our waterfowl resource and get some degree of satisfaction out of contact with the resource are hunters. A much greater mass of people have a personal interest in our waterfowl resource, and it is the conversion of this group to a new evangelical zeal which I think will result in saving our remnant waterfowl lands in the future. The Fish and Wildlife Service, the respective States, and important professional wildlife and sound sportsmen's groups are now all knit together in the creation of specific flyway councils for waterfowl restoration and maintenance. Such plans, when perfected and detailed, will enable everyone to contribute to the preservation problem in a more practical way. This group are serviced by the technical waterfowl biologists of both state and federal agencies. From their contributions and review of waterfowl management plans and regulations, already restoration plans and annual hunting regulations have become more realistic and flexible. These groups seem to be avoiding to a favorable degree their main pitfall, namely, degenerating into pressure groups for local benefits and local segments of the hunting population. We can expect great benefits from the final permanent constitution of such councils.

Before closing, it would be well to recapitulate our remaining waterfowl needs in the way of basic habitat. There are only 30 million acres of first-class waterfowl habitat left in the country. From careful studies over the past 22 years, the Service has estimated and had confirmed by operating experience that not less than 12½ million acres of good waterfowl habitat should be in federal and state hands. The Service to date has restored 3½ million acres of first-class waterfowl habitat. It has been found that at least 7½ million acres should be federally owned to meet its international requirements under the various treaties and actually to preserve a safe and perpetual broodstock of waterfowl. As a minimum, 4 million additional acres must be preserved for waterfowl in the next 25 years, making a total of 7½ million acres of land to meet the federal responsibility. It is estimated that, through funds derived from the Federal Aid program, the States will be able to restore and maintain 5 million acres. We now have 4¼ million waterfowl hunters. Our population will increase, it is held, to 206 million individuals by 1975, and in view of great increases in the number of hunters in the last five years, it is safe to expect not less than 10 million waterfowl hunters by 1975. To maintain our waterfowl resource at its present level, we must have this basic 12½ million acres of waterfowl habitat safely secured in federal and state hands, for by 1975 I am confident that the only waterfowl habitat left in this country—save large expanses of sterile water represented by certain large lakes and reservoirs and our main river courses—will be that controlled by the Service and the various state fish and game departments. It is on these lands that we must maintain the waterfowl resources of the future. So, the time is short and the opportunity limited. Let's get busy!

DISCUSSION

CHAIRMAN RUHL: I am sure that there are some questions and comments. Mr. Farley, would you care to say something?

MR. JOHN FARLEY [Washington, D. C.]: I don't think that it has ever been my privilege to sit for an hour and a half in a discussion of migratory waterfowl problems and not get into the fields of controversy. I congratulate this panel on the fact that we possibly have not gotten into those fields. However, I would like to comment on a few aspects of the general subject.

The conception of the problem here as a football game has certainly interested me. With the size of that big gentleman standing up there I thought maybe he should be in the line instead of the backfield and perhaps we should readjust our teams a little bit.

The public representation is not limited, you know, to the backfield. This obviously is a professional game because most of the members are professionals with the amateur standing of the public represented here. However, the game has to be financed and it is the public that does that. The public buys the tickets, part of which are hunting license tickets and part of which are the duck stamps which they attach to those tickets and also other fees that go along with the sport. Therefore, we want, I am sure, a good team and some good work performed and so we do have to have the public to properly finance it. We have got to have a cheering section and not have people who will devote their whole time to the matter of throwing pop bottles at the officials and so on.

We have talked about some of the tools, some of the facts which we have to work with, but so far we have left out of the discussion quite a bit of the area of management which is very essential.

We have not talked about such things as how we do get a determination of seasons and bag limits and yet that is one of the essential things. I think that when we find this answer that we are going to make a great deal of progress. I think that we have to recognize, also, that the signals have to be called somewhere. I think that a great many of the signals must be called after consulting with the members of our team; after consulting with the people who are out watching the competition that is developing.

I think we should emphasize the need of someone calling the shots, calling the signals and taking the position of leadership in this game—that somebody has to take it for better or for worse.

I sometimes feel that we have a few too many centers on our team—fellows who have been well trained and are well able to pass the ball, but then we find them lacking when it comes to carrying the ball. Therefore, we do not need too many centers—we have to build up the backfield, we have got to build up the scouts (our research people), we have got to build up the cheering section so that the public will support the game and keep it going.

I think, in conclusion, that the whole picture looks rather good right now.

I wonder if I can make a comment on the Wichita situation, on the impasse that was reached with the Secretaries of the Army and Interior on transfer of the land. Inasmuch as it is impossible to find any means acceptable to the Department of the Interior to make the transfer, the only other way of accomplishing that is to resort to Congress and so I think that is exactly where it should be.

FUMBLES AT THE GOAL LINE

LES WOERPEL
Executive Secretary, Wisconsin Federation of Conservation Clubs, Stevens Point, Wisconsin

You all know of situations which you consider fumbles. Have you analyzed them to see if you could determine what caused them?

From the Horseshoe Lake Refuge controversy on through the government approved and paid for drainage of our midwestern potholes, the stories hold a frustration that is hard to duplicate from any other cause. They carry with them the futility of trying to stop a flood with your hands.

All of these fumbles indicate a lack of depth of understanding of the whole problem, ignorance of the fundamental principles of conservation in all senses of the word, or a cunning exploitation of a public resource for personal gain and glory; exploitation, not only of a game resource, but of the waters and lands, marshes and wetlands, watersheds and people.

It seems incredible that agencies dedicated to management of our natural resources can be so far apart in their understanding of what constitutes good management, or if they know, that they can lose sight of their objectives so soon because of political pressure, personal friendships and prejudices, personal power and greed, or for economic advantage. Uniform understanding of total conservation, and aims for the future, are imperative to accomplish a common program in cooperation with other agencies and other countries.

All of our major fumbles, although they seem varied and unrelated, can actually be laid to one cause, which is also the cause of many of our fumbles in all the fields of resource conservation. That cause is the reason we are losing the game of conservation. We won't lose that game tomorrow, or maybe the next day. We'll win a few plays here and there, enough to salve our conscience and lull our senses of responsibility. But if our present course continues, the realization of our loss of the game is going to come much sooner than you think.

This may come as somewhat of a shock to some of you who have been preaching lack of public support as the reason for our failures. Even the failure of public support is a result, not a cause.

It is my firm and honest belief that the major cause of slow progress in our game of Conservation, and of most of our fumbles, is a lack of an honest belief in the importance and loftiness of the cause to which many of you have dedicated your lives. Many of you do not believe, in your own hearts, that conservation of our resources, including our waterfowl, is destined to be the future salvation of men's minds, bodies and souls—or you are afraid to let your fellow men know that you do believe. You are not convinced that your cause is as important, if not more important, than that of Industry, Business and the Pubic Utility. You are not convinced that your form of conservation is actually better for the farmer, the land and water, the cover and fertility, as well as the game and fish, than that of the Army Engineers, the various Extension Services, the Soil Conservation Service, among all the rest of the agencies which dabble in the art of conservation sciences.

Keep this in mind as we run through a few examples of some of our recent fumbles.

Although relaxation of the duck baiting regulations in the three major trouble areas seems to be from different causes, their effect is the same. California's claim to a need for succor from the duck plague always reminds me of the muck farmer's plight in our own state. Muck marshes suitable for farming when drained have a nasty habit of forming in or near forests, and swampy forests at that. Generally it is just the kind of home that deer like. After clearing out openings in the forests and planting crops designed to make the muck farmer rich in the shortest possible time, a rude awakening is encountered when the deer feel that the truck crops have been planted for their personal benefit and take advantage of the banquet table set before them. All kinds of pressure is put on the state to pay the damage, kill off the deer, fence the truck farm, etc.

Farmers of the Great Plains States generally aren't recompensed for loss of winter wheat, rye and other succulent morsels ducks and geese appropriate for themselves on their way north in the spring. No one has yet insisted that these ducks and geese should be fair game to the hunter in the spring to prevent decimated and trampled fields from taking money out of the farmer's pocket. Yet there is just as much justification for it as for some of the other concessions we make.

Probably no animal does as much damage to farm crops as the field mouse, whose depredations cause the greatest loss due to a single cause on our continent's farms. The frequency and numbers of this creature is, to a large extent, controlled by game and fish departments and state legislatures by their management of the so-called predators. Would anyone assume that the State should protect the farmer from the mouse, or recompense him for his loss?

I feel sorry for the poor ducks that are unfortunate enough to decide to migrate over the State of Ohio. According to reports these ducks just couldn't live to reach the south or come back to breed unless the kind Lake Erie Marsh owners fed them to carry them over the state, which is apparently devoid of duck food, according to reports. Maybe there is something to the child's saying, when he tells his dad, "I love you to death." The Erie Marsh owners apparently feel that way about the ducks that come their way.

Political interference for any purpose is bad. It is especially bad when that interference is based on a lack of knowledge of the facts, disregard of the principles of public rights, and the prodding of disgruntled constituents.

Public Law 566, the so-called "Watershed Protection and Flood Prevention Act," was supported by sportsmen and conservationists all over the United States, because they were sure that it would help put a stop to promiscuous drainage of our Prairie Potholes, which were rapidly disappearing through the assistance of the Federal Government and ditch happy heavy machine owners. The bill was passed by the 83rd Congress in 1954.

Since the enactment of this law, four out of every six drainage projects in Minnesota, three out of every five in South Dakota and seven out of every twelve in North Dakota, as well as great numbers in the rest of the upper Mississippi flyway states, have been carried out under Public Law 566. Previous to the enactment of this law such projects had to be paid for over a period of time by the landowner. If the price was too high the project became "unfeasible." Now the farmer gets the price from Uncle Santa Claus gratis, all he has to do is drain his land and pay for some of the minor costs. Projects which were previously unfeasible now become feasible with the taxpayer shouldering that part of the load that made it "unfeasible" before.

The tremendous increase in drainage since the enactment of this law indicates that it is probably one of the greatest fumbles we have yet made, and if the "soil bank" plan some conservationists now envisage incorporates the practice of plugging up some of these drainage projects it will be another case of paying, not once, but twice for our mistakes.

While 30,000 acres seems like a drop in the bucket compared to many waterfowl projects, the Great Lakes States don't have many refuge and development areas belonging to the public any larger than that. In Central Wisconsin there is an area of that size which is one of the most beautiful marshes I have seen, both from the standpoint of diversity of flora and fauna and from the standpoint of opportunities for development for a waterfowl area without harming the other assets of the marsh.

Because Industry decided to use it as a reservoir for downstream paper and power mills, almost everyone in the state laid down and played dead. It didn't matter that for an investment of about $135,-000 the power company would receive the privilege of condemning close to $1,000,000 worth of property not yet in their ownership. It didn't matter that for a saving of about $195,000 annually by using water power over using steam power they would destroy well over a $400,000 income from the farms that would go under water and the industries that these farms supported, which sum, when multiplied through its trade channels, might easily reach an economy of around a million dollars a year. Neither did it matter that the sandhill crane or the prairie chicken used the area, or that hundreds of persons used it for fishing, hunting, berrying, picnics, and just plain enjoyment.

Although the state only derives 17 per cent of its power from hydro impoundments, it was considered imperative that this little $6,000,000 development take place, although several other power companies were building steam developments worth upwards of $20,000,000 each.

Anyone bold enough to suggest that there might be other ways of attaining the same goal of water conservation along the tributaries of the river by good land practices, small impoundments and cover plantings, and that the additional power needed could be derived from steam, was ruthlessly ridiculed and brushed aside, not only by the power interests, but by some of the controlling conservationists in the state.

In conjunction with the above case a state college sent its conservation class to the Public Service Commission hearing expressing to all who would listen their conviction that industrial values were greater than the conservation values, although I doubt that any of them, including the teachers, weighed more than a few ducks, geese, partridge, prairie chickens, and deer in a hunter's bag against a little more power and a few more jobs in the paper mills downstream.

How many of you have heard of "Millionaires Monday"? In other states where conditions are slightly different it may be called by other names. It applies to the practice of closing public blinds around the perimeter of our federal waterfowl refuges that have been recently opened for public use, so that private landowners surrounding the area could get, or sell, some shooting from their own lands.

A few years ago these perimeter blinds were established because the adjacent landowners had eliminated the public from participating in the harvest of the ducks and geese on the marsh after their money had been used to restore the area to use and production by the proper management practices. The elimination of the public had been so complete that only the rich, gifted or lucky had an opportunity to utilize the big marshes' assets in ducks and geese.

Now the trends are being reversed once again, to supply private hunting one or more days a week around the marshes, once again to the rich, gifted or lucky. Whether or not they take advantage of it, these people are now entitled to hunt the marshes seven days a week during the season, without contributing one cent more than anyone else who hunts ducks and geese, by using the public blinds while they are open, and reverting to their own or leased lands the rest of the week, while the public is limited to only those periods when the public blinds are open.

The trend toward gearing our conservation program to "Public Opinion" without greatly expanded efforts towards clarifying our stand to the public is one of our greatest fumbles. Public Opinion is notoriously lacking in the understanding of the ultimate aims for which this program should be directing our paths. It is notoriously selfish in extent, being based on more for a locality, personal advantage, or advantage over some other area, purely sensual pleasure from hunting and fishing, etc.

Georges Clemenceau, the Tiger of France, in speaking of the tyrannies of the Dreyfus Case at the turn of the century, said, "Courageous men defying tyrants are never wanting in history, but it requires true heroism to defy the tyranny of Public Opinion." How many of our people in the conservation field can lay claim to reaching that peak of heroism?

How can you rally the support of the Conservation Public, and keep it, when you expound at great length on the idealistic principles that should guide us and then forget them in your administration of our resources? How can the conservation public, especially that segment of it still learning the fundamentals of the business, find a common denominator on which to base its computations of the worth of our program if we preach one thing and do another?

The latest Department of Agriculture's Yearbook, *Water,* contains this gem, "Excess water becomes a problem when it interferes with tillage, land preparation, the development of plants, and harvest operations." Do you think that the people who wrote that believe that conservation goes any farther than drainage and bumper crops?

You have all seen administrators and conservationists back away from a clash with a Power Interest or a Drainage District. You have all heard their excuse that we need to save our wetlands—but not at the expense of increased employment, more power, or more agricultural products. With the great extent of the recreational business, who is qualified to state that retaining our wetlands does not create more employment than any of these other uses that people are dead set on putting these lands to?

There is no doubt that use of our recreational resources is rushing headlong toward that point where shear force of numbers will crush the remains of our dwindling opportunities.

Unless we look to that higher purpose for saving our recreational lands and waters we will continually fumble opportunities to make a good gain toward our ultimate goal. We need a purpose, the value of which far exceeds that of purely the wildlife that can be produced for the hunter and fisherman before we can even believe in the right and justice of our cause. Once we have that purpose we will be able to fight on an equal basis against the inroads of Industry, Business and the Public Utility. We will be able to fight the losses we have been sustaining on a much broader plane, with much more fervor and believing in the right and justice of our course.

That there are higher causes than the one we have been clinging to is attested to by many people in other walks of life.

In his *Happiness Through Creative Living,* Mr. Preston Bradley says, "Since your whole life is, or should be, a series of creative acts, you need to discover creative solitude and to learn how to use it.

"You will learn to look forward to these moments of solitude and learn to love them. You will also find that some settings are more conducive to solitude than others. . . . In my own case, I find that the beauties of nature always help. Some of the finest moments of Creative Solitude I have ever enjoyed have come as I sat in a boat on a lovely lake with my fishing rod in my hand. There is no peace in the world like that inside a patient fisherman as he calmly watches his line for the telltale ripples that mean he has a bite.

"The bank of a river under the willows, the broad sweep of a sunlit meadow, the cool shadows of a green forest, these are the refuges nature has prepared for man. In them his eyes, his ears and his mind are given a rest from those things which usually assault them. These scenes have a deep, peaceful quality that is transmitted to the heart of those who come to enjoy them. So whenever possible seek out the beauty that nature offers to aid in inducing Creative Solitude."

Probably most of you have had an uneasy feeling that the hunting and fishing you are trying to build up and maintain is not the ultimate goal that you should be working for. Possibly Mr. Bradley has come closer to the goal that we should be driving at than we have. Maybe we could be more sure of our aims and our efforts if we had embraced this higher concept of what conservation means than we have been in our concept of trying to give more and more fish and game to more and more hunters and fishermen.

But Mr. Bradley isn't alone in his understanding of the primary purpose of trying to save the out-of-doors for the future. That old Master, Aldo Leopold, expresses the same view in his *Round River.*

"We have realized dimly, of course, that a day afield was good for the tired businessman. We have also realized that the destruction of wildlife removed the incentive for days afield. But we have not yet learned to express the value of wildlife in terms of social welfare. Some have attempted to justify wildlife conservation in terms of meat, others in the interest of science, education, agriculture, art, public health, and even military preparedness. But few have so far clearly realized and expressed the whole truth, namely, that all things are but factors in a broad social value, and that wildlife, like golf, is a social asset.

"But to those whose hearts are stirred by the sound of whistling wings and quacking mallards, wildlife is something even more than this. Golf is an acquired taste, but the instinct that finds delight in the sight and pursuit of game is bred into the very fibre of the race. Golf is a delightful accomplishment, but the love of hunting is almost a physiological characteristic. A man may not care for golf and still be human, but the man who does not like to see, hunt, photograph, or otherwise outwit birds or animals is hardly normal. He is supercivilized, and I for one do not know how to deal with him. Babes dc not tremble when they are shown a golf ball, but I should not like to own the boy whose hair does not lift his hat when he sees his first deer. We are dealing, therefore, with something that lies pretty deep. Some can live without opportunity for the exercise and control of the hunting instinct, just as I suppose some can live without work, play, love, business, or other vital adventure. But in these days we regard such deprivations as unsocial. Opportunity for exercise of all the normal instincts has come to be regarded more and more as an inalienable right. The men who are destroying our wildlife are alienating one of these rights, and doing a terribly thorough job of it. More than that, they are doing a permanent job of it. When the last corner lot is covered with tenements we can still make a playground by tearing them down, but when the last antelope goes by the board, not all the playground associations in Christendom can do aught to replace the loss."

John Wanamaker has said, "People who can't find time for recreation are obliged sooner or later to find time for illness."

We know that unless we can save and improve our wetlands and other recreational resources in sufficient amounts to meet a public demand, unless we administer them for the good of the resource, and impartially, we will be contributing to the filling of hospital beds in both physical and mental hospitals of the nation in the future.

We are rapidly nearing our last goal line. We are inviting the final fumble which will mean that we have done too little and too late. Then we will recognize that all the fumbles that had gone before should have warned us that we had been more concerned about the plays and the cheers of the crowd than we had been about the game, and winning. That most of our previous fumbles were caused by the lack of a goal of sufficient importance to make the game worthwhile and make us expend every effort possible toward reaching that goal without digression to values of less importance.

The Prudential Insurance Company's motto is "The future belongs to those who prepare for it." Can you think of a more apt motto for sportsmen and conservationists?

Business and Industry set their goal because they believe in it, and it takes a major catastrophe to swerve them from their purpose. That is one reason why they have been winning all, or most, of their games with us—because they have believed in their goal above all else. They have believed that the goal they have set in each one of the controversies *must* be reached to gain the ultimate score to win the game. They MUST be reached to gain the ultimate score to win the game. They don't digress, they don't concede, they seldom compromise. They are gaining their goal and winning their game.

Conservationists *can* accomplish the same results. They *can* believe in their program just as thoroughly if they are careful in setting it up and look to the future for the need, as Industry and Business do. They *can* convince the public that their cause is just as important, if not more so, than that of any other segment of society, if they will just believe in their own cause themselves, and base their programs on the higher needs of the future rather than on a few more ducks, a little more shooting, or a little more game in the bag.

It's time we quit stressing the need for more ducks and geese, pheasants and quail, prairie chicken and sharptails, rabbits and deer, and get down to convincing ourselves and the public that it is imperative that we begin to save our waters and our lands, our swamps and our marshes, our trees and shrubs, our watersheds and our people, by adhering more closely to the principles we insist should be the guide for others.

Yes, we've made a lot of fumbles, some of which have been extremely costly. We've put ourselves behind the 8 ball many times, because we have operated piecemeal because we have not had an ultimate, clearly defined goal, or a cause of sufficient importance to compel our undivided support. It isn't too late to learn from some of our past mistakes and make up the yardage we need. It can be done by setting our eyes to a new, broader, more important goal which will give the participants in our game the pride, courage and determination to carry the ball over.

DISCUSSION

DR. E. H. GRAHAM [Soil Conservation Service]: I think, if I heard the speaker correctly, that he indicated that a large percentage of drainage which is being done in some of the north-central states was being done under Public Law 566 or the Small Watersheds Act. Therefore, there must be some confusion as to how this drainage was done. The usual criticism that is directed to the Department of Agriculture with respect to 566 is that we are too slow and that we haven't gotten under way but then I want to make it clear that this drainage to which he referred was not made under the Small Watersheds Act.

One other point. In the development of the Small Watersheds Program, the program or plan is developed by a local sponsoring group of some kind or other. That program is then referred to a state agency appointed by the governor for review before it ever gets to Washington.

Those of us who are concerned with wildlife and the recreational aspect of the small watersheds program have, if we will, an opportunity to work with those who are developing the projects at the local level and at the state and national levels. This is an opportunity that we do not want to get confused about. It is one of the greatest opportunities that we have had to date. It is up to us to be quite clear about the facts involved and about the opportunities this program affords.

MR. WOERPEL: The only comment that I would like to make to that is that I believe that the records of the states stand by themselves. The records were derived from that source and I think they speak quite clearly of themselves.

MR. T. R. EVANS [Illinois]: I think that Mr. Woerpel has presented some real pertinent facts to us here. I am sure that we all agree that we have made plenty of fumbles all along the line. However, I feel that probably a good many of us are not willing to concede that these fumbles are due to what you may have termed a lack of proper attitude or not a real firm belief in the cause for which we are fighting.

I just wonder if you have some basis for the belief that this has been a real contributing factor to our fumbles, and, secondly, would you say that it applies particularly to the professionals in the game or to the cheering section of sportsmen, or possibly others?

MR. WOERPEL: Well, Mr. Evans, I anticipated a question of that kind and so I wrote down some points here. I would be glad to read those in answer to thta question.

Some of the reasons I do not believe some of our leading conservationists are actually sold on the importance of their program or professions are as follows:

1. They make too many exceptions of expediency to the generally accepted "right" practices of management and regulation (I base my concept of "right" practices on the writings of such men as Gabrielson, Leopold, Allen,

Eschmeyer, Carter, Wing, Greeley, Schultz, etc. in which they partially or wholly agree as to the "right" practices).

2. They try to judge economic feasibility of industrial projects and the relative merits of conservation against industrial worth. This is a predominant course even when other agencies of State or Federal Governments are charged with making the determination. Because these conservationists are not competent to judge the relative merits the conservation cause loses many unnecessary cases.
3. They are publicly unsure of themselves and their programs and are afraid to pit their programs against the test of Public Opinion. When they are in conflict with public opinion they tend to "give in" or compromise rather than to stand back of their programs and defend them agianst ignorant public argument. (Wherever *honest* administrators have stood up to public opinion defending their programs they have won the respect and a willingness of the public ot go along with them.)
4. They are unwilling to accept honest criticism of their programs. Some take the stand that their critics are "out to get them" or are trying to tear down their departments. (We found that administrators who have good, sound, honest programs are not afraid of public opinion or criticism, but that those who have poor programs based on an inordinately large amount of control by/or for/ private interests use this as a defense mechanism and even go so far as to try to isolate the critic from contact with their department personnel.)
5. They place too much emphasis on supplying game and fish to the gun and rod even if it has to be done by artificial propagation and in spite of the comparatively high cost for returns to the bag. They have the false conception that conservation *IS* hunting and fishing and that their program can be judged by the number of game and fish that they plant. (In this sense they are equally guilty with other so-called conservation agencies of narrow mindedness and class administration for selfish reasons and whose concept of conservation is more agricultural products, more water power, more forests, more brush free roadways, etc.)
6. They have a guilt complex when their programs succeed. Because they have been able to increase ducks, they feel guilty about the amount of food these ducks appropriate, even if the food is in human surplus and the areas were originally duck areas and the agriculturalist is the intruder. Because they have been able to build up deer herds they feel guilty because deer eat young trees or truck crops, even though the deer is a part of the forest and again is the native with the truck farmer the intruder, etc.)
7. They refrain from pushing their programs when they are in conflict with other agencies, claiming restrictive laws or ethics, although those in public service opposed to their programs have no fear of such restrictions or ethics, and actively and vocally act in their own behalf.
8. They refrain from entering major policy and administration confiicts with the U. S. Government, such as the uncontrolled subsidy program (although it depletes lands needed for the future to grow crops not now needed and diverts money ill afforded). The Big Dam Irrigation Projects (although they add lands unnecessary to production, depleting future reserves unnecessarily, and diverting money ill afforded). The drainage craze (although it endangers the future water supply of the nation as well as returning unneeded land to production of surplus crops and diverts money ill afforded), etc.
9. And because they do not, in the words of George Washington, "Labor to keep alive in their breasts that little spark of celestial fire — conscience."

MR. SETH GORDON [California]: I am not going to defend California for we do not need any defense, but I am going to defend the public administrators who are in this room and who serve in both this country and in Canada and then I am sure that the folks over in Mexico also are trying to do their best.

I do not particularly enjoy the inference that most of the public administrators do not have the backbone enough to stand up and defend their programs. Those of us in this room who have worked at this problem for years, have had the backbone to stand up or we would not be here. The ones who do not have the backbone have left us long ago.

I think that most of us have tried to do the job that we were supposed to do and if there have been times when we apparently did not have the courage to complete the job it is because the backfield wasn't there to support us and we stood alone.

Now, the inference that the public administrators are a bunch of jellyfish is not a wise thing to say in an audience such as this. It is not a very proper statement to make in behalf of the state of Wisconsin because I know something about the early history up there.

I am sure that throughout the years there has been evidence of a great deal of courage in playing the game but then there has also been throughout the years a lack of support from the backfield for many of the things we have called attention to. That is all that I wish to add. However, I do agree with the other aspects of the paper and with the other speakers that we are making progress.

CHAIRMAN RUHL: Are there any other comments. I do think that I should give the members of the panel a chance to have a last word if they so desire.

MR. WOERPEL: I would just like to point out to Mr. Gordon that probably the worst place to give that paper would be here because by the interest of the administrators in being here they have proven a point, that they are willing to go all out for their programs. However, I am sure that Mr. Gordon and all of you will have to admit that there are a number of them that do come under that category.

One of the things that Mr. Gordon must remember is that he sits in the administrator's chair and I sit down with the public. I find out more quickly when people are not satisfied with these programs.

I think that we have to take hold of this matter that Mr. Farley mentioned a while ago, as to whom we should look to for information. As it is now the various groups contradict one another. We are not technicians in the field of conservation but then we are trying to make the best with what we have got and I think from that point is where we get a lot of our confusion and it is one of the reasons why we have so much difficulty in getting the public behind our programs.

CHAIRMAN RUHL: I think that Les would agree that we could draw up quite a long list of fundamentals in connection with the organized sportsmen but then I don't know whether it would do any good. I think, however, that we sometimes do underestimate the number of people that are for us because the people who are against us are close and they are also loud and persistent. Those who believe in the program are apt to take for granted that it will come to pass.

I think that one of the things that we need here is a so-called head coach in addition to the local, state and private organization, who are line coaches. I don't think that we have yet perfected the leadership for a head coach.

I think another thing is that a football team to be successful must develop a system of play that takes full advantage of the strong points and the strong characters of the material they have on their side. They should also be able to take advantage of the weakness of their competitors.

There is quite a problem here with equipment and that is something that is understood. One of the things that we do not talk much about is recruiting. I think it is important that both the public and private agencies have a real system of recruiting our fair share of the best brains to be used in this field if we are to be successful.

Of course, we have to have rules and regulations but then we also have to have capable referees and they are chosen because they are particularly well qualified to make good decisions on the spot and to make them stick.

I don't know how much or what we should do with the picking of the referees but certainly the coaching staff and the alumni in the stands, the private organizations, need to do what they can to see that the best qualified and impartial referees are available.

MR. SELKE [Minnesota]: I think that in this reference you have missed something and that is the reference to touchdowns. I have reference to the scoring. I think that we should consider the scoring in the future and thus the next time we meet let's consider the touchdowns.

MR. SETH MYERS [Pennsylvania]: I think that another thing that we have forgotten about in our discussion of football teams are the sports writers. I think that if we are going to get this story across to the general public that we will need to have less controversy and less jockeying for recognition and have a more integrated effort on the part of all who are carrying on the work of trying to conserve the natural resources and natural heritage of mankind.

PART II

TECHNICAL SESSIONS

TECHNICAL SESSIONS

Monday Afternoon—March 5

Chairman: HAROLD D. BISSELL
Fish and Game Laboratory, Department of Fish and Game, Sacramento, California

Discussion Leader: S. C. WHITLOCK
In Charge, Game Research, Department of Conservation, Lansing, Michigan

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DISEASE, NUTRITION, AND CONTROLS

WILDLIFE IMPLICATIONS OF HARDWOOD AND BRUSH CONTROLS

PHIL D. GOODRUM
U. S. Fish and Wildlife Service, Nacogdoches, Texas, and

VINCENT H. REID
U. S. Fish and Wildlife Service, Alexandria, Louisiana

The increased demand for forest, range, and other agricultural products since World War II has focused greater attention upon more efficient use of land to meet this objective. This growth is attributed largely to the rise in value of livestock and wood products. As a consequence, the livestock industry has sought better range improvement methods, including the reduction or elimination of trees and brush. Likewise, foresters have accelerated their program to eliminate or reduce certain hardwoods and brush to get better growing conditions for conifers.

Some concept of the enormity of the hardwood and brush control program may be gained from surveys of the acreages of the various species subject to control. According to Hughes (1953), there are 250,000,000 acres of brush land in the United States that should be controlled. Darrow (1955a) has provided acreage figures for several species on range lands in Texas, Oklahoma, Arizona and New Mexico. They are: mesquite (*Prosopis* spp.), 70,000,000 acres; sand sagebrush (*Artemisia* spp.), 7,000,000 acres; sand shinnery oak (*Quercus* spp.), 15,000,000 acres; white brush (*Aloysia lycioides*) (Texas only), 8,000,000 to 10,000,000 acres. He lists 11,000,000 acres of post oak (*Quercus stellata*) and blackjack oak (*Quercus marylandica*) in Texas alone. There are additional millions of acres in nearby states, especially Arkansas, Oklahoma, Missouri and Louisiana.

Burcham (1955) says that the problem of undesirable woody vegetation on foothills ranges of California centers in some 20,000,000 acres of land outside the commercial timber area that needs control.

Commercial forest interests also feel the need of improving their stands by habitat manipulation. For example, Forest Survey Release 75 (U.S.D.A., Forest Service, 1955) indicates that more than 6,000,000 acres of commercial Louisiana pine stands are in need of timber-stand-improvement work to eliminate undesirable hardwoods.

The development of methods of habitat manipulation to favor desired products has been tremendous. The purpose of this paper is to show the growth and development of means to control environments and the lack of parallel studies to show the possible impact of such efforts on wildlife.

MEANS OF ENVIRONMENTAL CONTROL

For many years environmental changes were limited to fire, clearing, draining and flooding. Now it has advanced to a stage where selective or mass elimination of habitat components may be accomplished by mechanical and chemical means. The girdling ax, little beaver, bulldozer, brushcutter, chaining and cabling methods of plant community control are being augmented by herbicides.

It is not our purpose to go into a discussion of all the chemicals or their particular use in the control program. However, the most widely used chemicals in plant control research and in commercial operations are 2,4-D (2,4-dichlorophenoxyacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), mixtures of these two, sodium arsenite, and ammate (ammonium sulfamate). Other chemicals that have received attention are: TCA (trichloracetic acid), sodium chlorate, borax (sodium borate), dinitrophenol compounds, IPC (isopropylphenyl carbamate), Dalapon (2,2-dichloroproprionic acid), chlorinated benzenes, aromatic solvents (naphthas), CMU (3-(p-chlorophenyl)-1,1-dimethylurea), delrad (dehydroabietylamine acetate), and copper sulfate (Springer, 1955; Rudolf, 1951).

The chemical control of woody plants has become an accepted practice (Rudolf, 1951) and is now being used on water areas, farms, rights-of-way, ranges, and forests. There is little question that the use of chemicals holds great promise for the improvement of range and forest lands for the production of high-value livestock and forest products. Furthermore, chemical control may be useful in conditioning game range, but so far we know little about it. We know even less about integrating and coordinating these uses.

FIELDS OF ACTIVITY

Farm land. Clean farming by mechanical means has been a potent factor in the reduction of wildlife habitat by eliminating fence rows, weeds and crop residues. It appears now that herbicides will accelerate this trend toward cleaner and cleaner farms. Recent investigations (Chaffin, undated; Hall, 1952; Hamilton and Buckholtz, 1953) indicate that herbicides can be made to kill unwanted weeds in field crops. At least 78 farm weeds can now be controlled with herbicides (Chaffin, undated).

Range lands. Over the past fifty years, the spread of weed species, including forbs and woody plants, has been great (Burcham, 1955; Costello, 1941; Parker and Martin, 1952), reducing the quality of pasture and range land in many sections throughout the United States. Ranchers have been battling these "weeds" for many years in an attempt to hold or improve grassland. Recently it appears that the use of herbicides is helping to achieve these goals. One of the objectives now is to convert brush and marginal forest to open range land (Darrow and McCully, 1954a and b; Darrow, 1955a and b; Elwell and Elder, 1954; Kissinger, Hull and Vaughn, 1952; McCully, 1955b; Young, Anderwald and McCully, 1948; Thompson Chemicals Corporation, undated; and many others).

Commercial forests. In the commercial timber lands of the nation, foresters are heralding the use of herbicides as a great tool for the reduction or elimination of so-called worthless or low-grade tree species and brush which interfere with forest regeneration or harvest of more desirable commercial species, especially pine, and to improve grazing. Recent research has been aimed at the improvement of both mechanical and herbicidal treatment, such as soil injection, trunk or frill application, and ground-level or aerial-foliage spraying, to kill unwanted tree and brush species (Bull and Campbell, 1949; Campbell and Peevy, 1950; Chaiken, 1951; Goddard, 1954; Grano, 1953; Cassady, 1952; Darrow and McCully, 1955; Martin and Clark, 1954; Peevy, 1953; and many others). Application of these methods are following quickly on the heels of research.

WILDLIFE IMPLICATIONS

The management tools of plant community control for the farmer, range man and forester are also the tools of the wildlife manager. The problem of maintaining suitable wildlife habitat involves the retaining or development of diversified habitat of quality plant species to provide forage, mast food and cover. "Quality" here means the kind, form and distribution of plants that meet the requirements of wildlife.

Some wildlife workers have pointed out how vegetation control can be employed for the benefit of wildlife. Krefting (1941 and 1955) showed that ground-line and snow-line cutting of several plant species increased the amount of quality deer browse, and that breast-height spraying of herbicides increased regrowth of mountain maple deer browse.

Herbicides have been used effectively to condition sharp-tailed grouse and waterfowl habitat in Wisconsin by creating and maintaining open areas (Hartman, 1956).

A good example of how herbicides may be used to achieve specific benefit to wildlife is the control of honeysuckle in wildlife borders (Warbach, 1953). Honeysuckle (*Lonicera japonica*), itself, is a good wildlife plant; but, in wildlife borders, it suppresses more valuable plants.

Pound and Egler (1953) tell of a strip of low, relatively stable plant cover, accomplished by mechanical means, which has persisted for 15 years. They suggest the possibility of accomplishing similar plant community conversions with the selective application of herbicides. Such plant management has utility in rights-of-way and fire-lane management and as a wildlife management tool in maintaining "edge" in large contiguous forest covers.

In California, bulldozing, control burning, and chemical spraying are being employed to make deer range more productive (*Outdoor California,* 1955).

However, mechanical and chemical controls on plant communities can be a "two-edge sword" when dealing with wildlife. The literature reveals a wealth of detail on the killing qualities of mechanical agents and chemicals on specifically "unwanted" species for farm, range and forest, and the terms "undesirable," "unwanted," "weed species," "culls," and other terms with similar connotation appear throughout. But, are these plants necessarily "weeds" to the wildlife manager?

In preparing this paper, a list of plants sensitive to herbicidal treatment was prepared. The list, no doubt, is incomplete, inasmuch as all species on sprayed areas have not been studied, but about 92 genera, including some 225 species of woody plants, are susceptible to herbicides. The list suggests that broad-leaved species in general, but in varying degree, are affected.

The list is indeed imposing, and the wildlife worker will recognize some of these "unwanted" species as salient wildlife food and cover plants. For example, in the Lake States, combinations of 2,4-D and 2,4,5-T, if applied at the proper growth stage, can top-kill 35 species of woody plants in one application. With repeated applications, 32 other species can be top-killed. Some of the susceptible plants are as follows: green ash (*Fraxinus pennsylvanica*), wild blackberry (*Rubus* spp.), black cherry (*Prunus serotina*), chokecherry (*Prunus virginiana*), pin cherry (*Prunus pennsylvanica*), red maple (*Acer rubrum*), mountain maple (*Acer spicatum*), northern red oak (*Quercus borealis*), white oak (*Quercus alba*) and sassafras (*Sassafras albidum*) (Rudolf, 1951).

In the west, attempts are being made to control big sagebrush (*Artemisia tridentata*), an important food for many kinds of wildlife (Kissinger, *et al.*, 1952). *Ceanothus* spp. is recognized as an important wildlife plant, yet it is one of the species subject to control in the range improvement program.

Other plant species of recognized wildlife value that are susceptible to chemical treatment include whitebrush (*Alvosia lycoides*), dogwood (*Cornus* spp.), hawthorn (*Crataegus* spp.), persimmon (*Diospyros virginiana*), gallberry (*Ilex* spp.), sweetgum (*Liquidambar styraciflua*), blackgum (*Nyssa sylvatica*), mesquite (*Prosopis* spp.), greenbrier (*Smilax* spp.), blueberry (*Vaccinium* spp.), sassafras (*Sassafras* spp.) and yaupon (*Ilex vomitoria*).

In the commercial pine forests of the Southeast, undesirable hardwood and brush control work is aimed primarily at the oaks. It is common knowledge that oak mast is an important source of highly nutritious food for wildlife. Van Dersal (1938) lists 49 species of birds and several species of mammals which utilize oak mast for food. Martin, Zim and Nelson (1951) list 96 wildlife users of oak.

Scrub hardwoods have increased since the virgin forests were cut. If there was a great loss to wildlife by the cutting of virgin pine stands, the loss has been somewhat lessened by the increase of hardwoods in the pine woods. Since the 1930's, the removal of quality wildlife hardwood trees through harvest, mechanical control measures and more recently by the use of chemical herbicides could result in further deterioration of wildlife habitat values.

If wildlife is to be considered in the multiple use of the forests, then best use should be made of oaks in habitat manipulation. Knowledge of productive ability and factors influencing mast yields should be understood. Downs and Quilken (1944), Downs (1944), Cypert (1948, 1951), Burns, Christisen, and Nichols (1954), and Christisen and Korschgen (1955) have reported on oak production studies and factors influencing yields in deciduous-type forests. Knowledge concerning oaks that inhabit pine-hardwood and pine forests is also needed.

Observations and study have been made of several oaks in the southern pine region. These include sandjack or bluejack (*Quercus cinerea*), blackjack (*Q. marylandica*), postoak (*Q. stellata*), southern red oak (*Q. falcata*), water oak (*Q. nigra*), white oak (*Q. alba*), and cow oak (*Q. primus*).

All species of oaks do not necessarily have good mast yields the same year. This was exemplified in 1955, when sub-freezing temperatures occurred in North and Central Louisiana the latter part of March when the oaks were flowering. Where the freeze occurred, few acorns were produced on the white oak group in 1955. This group matures its acorns in one season. However, oaks belonging to the black oak group produced good crops in 1955. It takes this group two seasons to mature its acorns, and the damage done to the mast crop by the March, 1955, freeze will show up in 1956. A variety of species of oaks is essential in insuring yearly mast production and should be considered in wildlife habitat manipulation.

The density of the tree stand has an important bearing on mast yields, but there is some variation between species. Smaller species can tolerate greater stand density than larger tree species and yet give good mast yields. For example, sandjack, a small tree, showed that stand density had less influence on its mast yields than it did on larger oak species such as white and water oak.

Quality trees, from the standpoint of mast yields, were trees with large crowns in relation to bole diameter. Stands could be thinned to allow full crown development and higher mast yields maintained. However, this type of tree is the one most likely to be culled from the pine stands because of the space it takes in the forest stand.

With the exception of sandjack, few of the oaks begin substantial production before the age of 20 years or diameter size below five inches. Sandjack will begin production earlier, about 15 years, and at smaller diameter size. The larger trees, such as water oak, southern red oak, white oak and cow oak produce best when they are more than 30 years of age and above 10 inches in diameter.

Variety in a forest makes a more favorable game habitat. Variety in species of trees, shrubs and herbs, as well as in openings and tree stand density, is important in good forest game range. The oaks in the southern pine forests help satisfy these requirements.

The current trend is toward more intensive management of farm, range and forest. In this stepped-up program, plant community management or control is aimed to favor specific plant forms of high or immediate economic value. Many species of value to wildlife are subject to control and labelled as "weed" species. Is there a place for these "weeds" and associated wildlife in the current land management program?

SUMMARY AND CONCLUSION

The increased demand for forest, range and other agricultural products since World War II has focused greater attention upon ways and means of getting more efficient use of farm, range, and forest lands. To achieve these goals, range men and foresters, in particular, have sought better methods of reducing or ridding their lands of so-called undesirable hardwoods and brush.

The objectionable species include many species such as postoak, blackjack oak, sandjack oak, liveoak, shinnery oak, mesquite, whitebrush, sagebrush, alder, poplar, red maple, hazel and many others.

The control of hardwoods and brush by mechanical methods is rapidly being augmented by herbicides, including application by air. The chief chemicals being used are 2,4-D and 2,4,5-T, but several others are being tested.

A great deal of information is now available on the effect of mechanical and herbicidal control on the "weed" species, but little is known of the effects on other vegetation or the over-all effect of the herbicides on habitats and the wildlife therein. It is obvious that control operations may result in both good and bad effects on wildlife, and range and forest owners are entitled to know what these effects are.

Apparently, it has been assumed, in the absence of research, that reduction or elimination of certain "weed" species has little or no effect on wildlife. Yet, we know that most broad-leaved plants are affected by herbicides in varying degree. The non-selective application of herbicides, especially by air, may be particularly hazardous to mast-bearing species like the oaks since it is known that top-kill usually occurs, although the plants may not be killed outright. It is common knowledge that mast constitutes an all important source of wildlife food.

Herbicide research workers now feel the need for more facts on the vegetative regeneration process of the various species and the action of the chemicals on and in the plants in order to better control them. Likewise, we need basic biological data on at least the more important wildlife plants in order to intelligently conduct habitat improvement work.

For example, in southern pine forests several species of oaks provide diversity and food for wildlife, but in specific localities the oaks need selective control to best service wildlife as well as pine timber production. Dense stands of oaks should be thinned leaving an adequate number of quality trees of each species. "Quality" trees are those with large crowns in relation to diameter of the trunk. However, at present, these are the kind of trees most likely to be culled by the pine culturist because of the space they occupy. The various hardwood species begin mast production at different ages, and these should be known before control is undertaken.

The livestock and forest industries are not the only ones who have a stake in range and forest. A large segment of our people are interested in range and forest in a broader sense. They look upon these lands as a place for recreation, a place to hunt and fish. Furthermore, many forest and range owners are interested in multiple use of their land, but do not realize the potentialities of the good and bad effects of environmental control. These people are entitled to facts about these good and bad effects on wildlife. The responsibility apparently lies with professional wildlife people to make this information available since they are not getting it from other sources.

Does the "weed," defined by the dictionary as any unsightly or troublesome plant that is at the same time useless, have a place in the conservation field? Is a ragweed or goatweed seed to a dove, a partridge pea seed to a quail, an acorn to a squirrel, duck, turkey or deer, or a mountain maple twig to a deer, a useless product from a troublesome or unsightly plant? Are we "pulling together for conservation" in the intensive management programs?

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DISCUSSION

MODERATOR WHITLOCK: I am sure that this paper must have raised some questions on your part. Possibly some of you may already have ideas about this new development, you might say, in forestry or in agriculture or wildlife management that affects all of them, as to just what this is going to mean in the future.

He brought up the question that there are some possible areas of disagreement that may exist between the commercial forestry people and the wildlife management or game people, at least in some states where the wildlife values are of more importance than they are in others.

Speaking from my personal knowledge in Michigan I can say that our foresters, and that includes the federal as well as state foresters, are thinking about this right along with us. They are looking at this strictly from the soil life proposition.

Now, I would like to hear some expression of opinion from the audience on this paper.

DR. WALTER P. TAYLOR [California]: Mr. Goodrum, did I understand you to say that there are twenty million acres of brushlands in California?

MR. GOODRUM: That is in the foothills.

DR. TAYLOR: The implication being that they should be eliminated?

MR. GOODRUM: That is what the man said here.

DR. TAYLOR: It might be interesting to this group to realize that we figure the brushlands above Los Angeles Valley to be worth several hundred dollars an acre for the protection of watershed and other values in the valley below. These brushlands are one of our most valuable possessions to date. The Forest Service people and others are trying to find better plans in connection with protecting the hills. However, thus far the brushlands are of excellent value to us and it would be terrible to leave the impression that they be eliminated.

MR. DELLINGER [Arkansas]: We have that problem of the killing of many of our oak trees. First the foresters came in and started girding them, and then the cattle men started spraying them. This is going to change the area markedly and I don't know whether it is all going to be bad. We have, in the Ozarks, quite a bit of land covered with blackjack oak and they never will be large enough or good enough to cut for timber. They have been spraying and killing around 90 per cent. Then within a year after that the area is covered with grasses much like that they have in the plains to the West, where they are grazing about one cow to every ten acres. We get a good coverage of grasses and with the seed, of course, we are having a good many quail come in. Quail, of course, are very desirable game species with us. This change has also brought in a lot of rats, snakes, hawks and owls. I don't know how long this will last. I think that they will have to continue spraying. If it killed out all of the brush, then I am sure that we would all oppose it because it would make the land less desirable for turkey and deer and other wildlife.

MR. ROY GRIZZEL [Georgia]: Can you tell me if there have been any definitive studies made as to how this elimination of the so-called weed species will actually affect various populations, say of deer, turkey and quails?

MR. GOODRUM: That is something that has not been measured.

MR. GRIZZEL: I think, for the record, that it would be a wonderful thing if we could get some definitive studies made on just how these various programs will affect our wildlife population because there is a lot of talk about it. However, we need some information that we can present when we talk to the foresters.

MR. BEN GLADING [California]: I would like to get into the discussion by saying that there is a vast movement to remove large sections or many thousands of acres of brush for increased grazing, both for deer and livestock. This is something that has been a subject of continuing study in our state.

CHAIRMAN BISSEL: I think that we will have to call a halt to this discussion here for we are running a bit behind. I think that the other comments in connection with this particular paper had better be reserved until after the meeting.

PROTEIN AND PHOSPHORUS CONTENT OF BROWSE PLANTS AS AN INFLUENCE ON SOUTHWESTERN DEER HERD LEVELS[1]

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Food is the primary factor controlling game population levels. As pointed out by Allee *et al.* (1949: p. 236), "It appears to be a fundamental attribute of living organisms to tend to use all available food supplies." This has been known by game biologists, among others, for some time.

Although the importance of the supply, or quantity, of food has been long emphasized, only recently has the importance of the nutritive content, or quality, of food plants been recognized. Work done to date indicates that almost without exception low mule deer populations can be traced directly to either an insufficient quantity or poor quality of food (Hagen, 1953). The same can be said of white-tailed deer with the possible exception of the southeastern United States (Leopold, Sowls, and Spencer 1947).

Population levels are a direct result of the rate of productivity on one end of life and the mortality rate on the other. Food affects both of these.

Direct loss to starvation has been the central theme of a great majority of the publications that have recorded the history of deer management on the North American continent.

Loss of deer to disease and predation has usually been traced directly to an inadequate supply of highly nutritious foods. As pointed out by Taylor and Hahn (1947) practically all diseases of deer are due to inadequate nutrition. Cowan (1951) stated that "an animal

[1]A contributon from Pittman-Robertson Project 71-R (Arizona).
The author wishes to acknowledge the assistance of Mr. Clay Y. McCulloch and Dr. William R. Hanson, formerly biologists on the project. They assisted in planning the project, gathered the plant material for analysis and edited the manuscript. Thanks is extended to Messers. John M. Hall and Phil M. Cosper, Arizona Game and Fish Department, for their support on the project. The manuscript was read by Dr. A. R. Kemmerer, Department of Agricultural Biochemistry, University of Arizona; Mr. O. N. Arrington, Arizona Game and Fish Department; and Mr. Harold D. Bissell, California Department of Fish and Game.

in excellent nutritive condition . . . apparently acts as a poor host for parasites that would thrive on it were the animal undernourished.''

Commenting on big game populations in Canadian National Parks, Cowan (1950) stated that ''Malnutrition, winter tick, internal parasites and predatory animals made up the bulk of the destructive influences. The first alone, or in combination with parasitism, was the most important cause of death.''

Where food of big game is abundant, predation appears to have little depressing effect upon the population level (Leopold, 1950).

On the productivity end of the scale it has been demonstrated that deer on poor range have a lower rate of reproduction than those on ranges with an adequate supply of highly nutritious food plants (Cheatum and Severinghaus, 1950; Taber, 1953). The rate of survival of the young is also considerably influenced by the availability of nutritious forage (Longhurst *et al.*, 1952).

Since food is the dominant factor in the control of deer population levels, and nutritive values particularly warrant investigations where populations appear to be below normal, testing of browse species for their nutritive content was a major phase of a study of the deer in Arizona chaparral.

DESCRIPTION OF AREA

A detailed description of the chaparral region of Arizona has been given by Hanson and McCulloch (1955) and Nichol (1943). Briefly, soils are of granitic origin and extremely shallow. Slopes are precipitous. Shrub growth is dense and is mostly of the broad-leaved evergreen type. There is practically no understory of herbaceous material.

PROCEDURE

Clippings were taken from two general locations on and adjacent to areas where deer had been studied intensively. The Prescott area lies approximately 12 miles west of the city of Prescott and the Pinal Mountain area is located 8 miles south of Globe.

Portions of the current growth of twigs were clipped in April and July 1954, and January and March 1955. April clippings were made to catch plants at the peak of their growth. July clippings were made just prior to the summer rains when plants were dormant. January clippings were of dormant plants, and clippings taken during March were intended to be of plants that had been dormant the longest period, hence were at the annual low in nutritive value.

Analysis of rumen contents, field observations, and work of previous investigations (Nichol, 1938) indicated that certain browse species were preferred by deer. Those in this class were desert ceanothus (*Ceanothus Greggii*), mountain-mahogany (*Cercocarpus montanus*), Wright's silk-tassel (*Garrya Wrightii*), cliff-rose (*Cowania Stansburiana*), and holly-leaf buck-thorn (*Rhamnus crocea*).

Those plants classified by us as nonpreferred species were skunk-bush (*Rhus trilobata*), turbinella oak (*Quercus turbinella*), Emory oak (*Q. Emoryi*), Utah juniper (*Juniperus utahensis*), manzanita (*Arctostaphylos pungens* and *A. Pringlei*) and sugar sumac (*Rhus ovata*). The status of coffee-bush (*Simmondsia chinensis*) is still undecided. In desert areas it seems to be highly preferred, but in the chaparral it does not seem to be used extensively.

Controlled burning and breaking off of brush by dragging railroad rails behind a bulldozer have been suggested as possible habitat improvement measures in the chaparral. Tests of moisture and nutrient content were therefore made of plants from several burned areas and from one railed area.

To eliminate variation of nutrient content of individuals, clippings were taken from at least ten different plants, then combined to form a sample. The clipped material was immediately placed in jars and sealed to prevent loss in moisture content. The clippings were analyzed by the Department of Agricultural Biochemistry, University of Arizona, under a contract with the Arizona Game and Fish Department.

Because of the importance of protein to an animal's health and well-being, an analysis of crude protein content of the clippings was made. Phosphorus content was also determined, for it is known that this element is deficient on certain Arizona cattle ranges.

Moisture content of the plants was determined as there is a direct relationship between moisture, palatability, and digestibility. Stanley and Hodgson (1938) pointed out that young and growing plants, high in moisture content, are relatively high in digestibility and palatability, but these decrease as the plants become mature and dry.

Protein and phosphorus were expressed in terms of oven-dry weight.

Validity of the conclusions was statistically tested by a comparison of individuals (Snedecor, 1946: Sec. 2, 13).

PRESENTATION OF DATA

Moisture content. In general, moisture content of the plants was highest in April, declined to a low in January, and came up slightly in March. Intentions were to make the March collections prior to spring growing activity, but evidently plant growth had begun when the twigs were cut. The growth, however, had not progressed to the stage where new leaves were apparent.

During the period of growth moisture content of plants on a recently (1950) burned site in the Prescott area was significantly higher than that of plants on an older (1947) burn ($t = 6.937$; 3 D.f.) (Figure 1 and Table 1). There was little difference between moisture of plants from the older burn and from nondisturbed areas. Also, there was little difference in the moisture content of plants from burned and from nondisturbed sites during the dormant season.

When compared with clippings from nondisturbed sites, plants from the area railed in December 1953 showed a considerably greater amount of moisture during April and July ($t = 5.524$; 3 D.f.), but about the same moisture content during the dormant period (Figure 2). Growth followed a similar pattern. Sprouts on the railed area grew steadily from the first part of March to the middle of August 1954, while nonrailed shrubs ceased growing in May (Hanson, 1955).

The degree of use by both deer and cattle followed the general trend exhibited by moisture and twig growth. The disturbed sites were areas of concentrated use during the periods of high moisture content. On the railed area even turbinella oak, a species that is seldom used, received considerable browsing during periods of high moisture content. When the plants ceased growing and moisture content on the disturbed site dropped to that of plants from nondisturbed areas, concentrated use also declined.

A comparison of the seasonal moisture content of three preferred browse species (cliff-rose, mahogany and desert ceanothus) with three nonpreferred species (skunk-bush, turbinella oak and Emory oak) showed that nonpreferred species have more moisture in April and

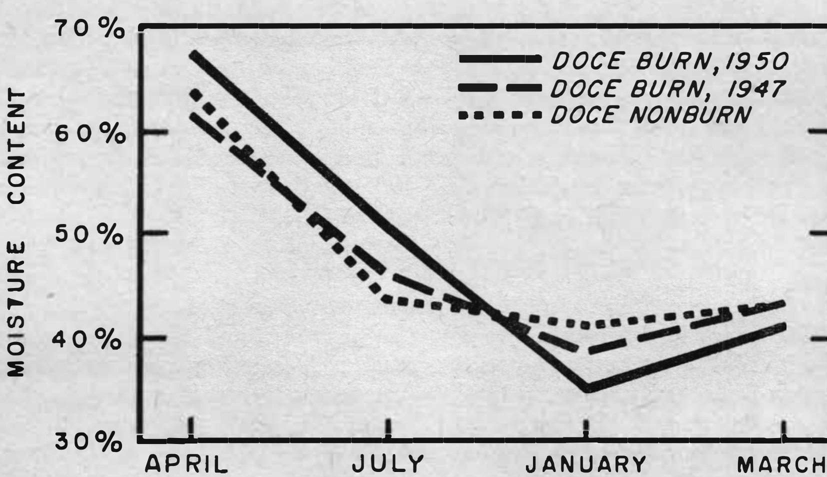

Figure 1. Seasonal moisture content of plants from burned and nonburned sites in the Prescott area.

TABLE 1. MOISTURE CONTENT (PER CENT) OF BROWSE SAMPLES COLLECTED ON THE PRESCOTT AND PINAL MOUNTAIN AREAS. 1954-1955.

Species	Prescott Area											
	Doce, 1950 Burn				Doce, 1947 Burn				Doce, Nonburn			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	66.0	53.8	36.3	42.7	61.7	48.0	38.5	43.3	60.9	46.1	38.4	41.3
Turbinella oak	70.0	50.0	32.9	36.2	64.8	44.1	34.6	38.6	64.8	44.5	34.8	38.0
Emory oak	67.8	52.4	28.4	39.3	64.7	48.8	39.8	44.2	68.6	47.6	44.4	43.4
Mountain-mahogany	60.6	46.1	36.9	42.6	57.8	41.0	40.3	44.8				
Wright's silk-tassel	71.7		45.0	48.7					57.6	39.2	45.2	48.0
	Railed Area				Buckman Flat				Woolsey Wash			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	73.5	60.0	35.2	42.8								
Turbinella oak	69.9	56.5	37.1	40.0								
Mountain-mahogany					57.6	37.0	41.0					
Cliff-rose					51.0	51.6	44.4	44.4				
Desert ceanothus					59.4	37.7	42.6	43.4		42.2	44.2	47.6
Utah juniper												
Manzanita (*A. pungens*)									50.6	45.8	43.6	47.0

Species	Pinal Mountain Area							
	1951 Burn				Nonburn			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	61.4	48.7	41.1		60.0	50.7	42.4	
Turbinella oak	64.9	43.5	41.7	43.9	57.2	45.9	31.8	42.4
Emory oak	66.9	46.2	44.2	40.5	66.0	49.0	40.7	40.2
Mountain-mahogany	61.8	51.6	42.4		62.4	42.6	39.2	
Wright's silk-tassel	68.0	51.0	48.7	49.6	67.0	46.3	43.8	46.9
Desert ceanothus	62.6	42.2	46.6		63.5	46.6	42.4	
Manzanita (*A. pungens*)	63.5	50.9	47.8		65.4	48.4	46.9	
Manzanita (*A. Pringlei*)		51.7	48.3	46.7		50.6	47.6	47.2
Holly-leaf buck-thorn	70.2	51.7	50.0	48.8	69.1	52.8	45.8	49.1
Sugar sumac	69.6	57.0	52.5	49.9	66.0	57.6	47.6	49.7

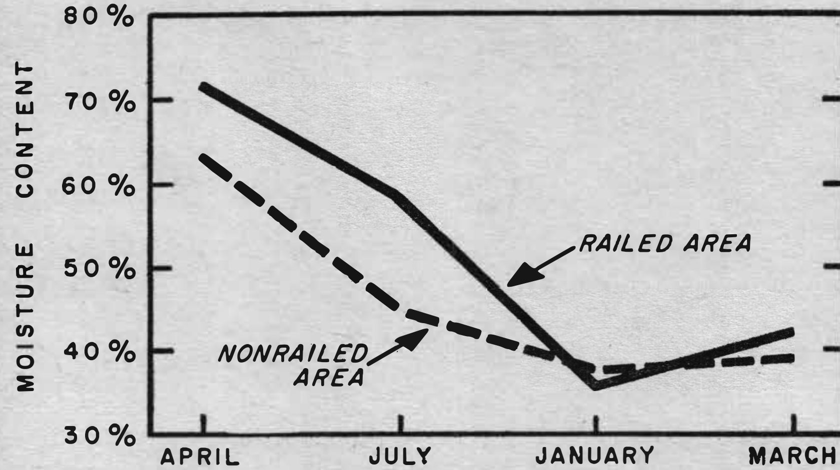

Figure 2. Seasonal moisture content of skunk-bush and turbinella oak from the railed site and an adjacent nonrailed site.

July, but that this condition is reversed during the dormant season (Figure 3).

Holly-leaf buck-thorn and Wright's silk-tassel, species that show heavy utilization by both deer and cattle, consistently had high moisture contents.

Apparently some species are not palatable regardless of moisture content. Manzanita consistently had a high moisture content, yet deer-

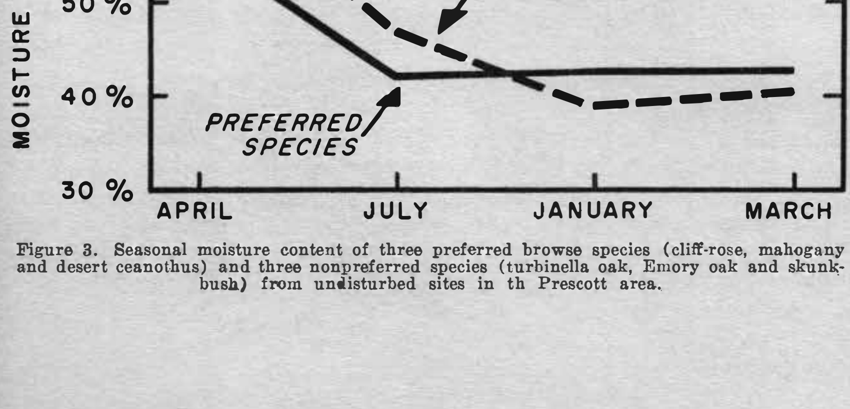

Figure 3. Seasonal moisture content of three preferred browse species (cliff-rose, mahogany and desert ceanothus) and three nonpreferred species (turbinella oak, Emory oak and skunk-bush) from undisturbed sites in th Prescott area.

TABLE 2. PHOSPHORUS CONTENT (PER CENT) OF BROWSE SAMPLES COLLECTED ON THE PRESCOTT AND PINAL MOUNTAIN AREAS, 1954-1955.

Species	Prescott Area											
	Doce, 1950 Burn				Doce, 1947 Burn				Doce, Nonburn			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	0.40	0.14	0.08	0.12	0.38	0.14	0.15	0.14	0.39	0.14	0.13	0.13
Turbinella oak	0.42	0.12	0.12	0.13	0.35	0.13	0.18	0.13	0.37	0.13	0.14	0.10
Emory oak	0.36	0.11	0.11	0.14	0.32	0.11	0.15	0.13	0.34	0.13	0.16	0.11
Mountain-mahogany	0.26	0.12	0.09	0.11	0.24	0.12	0.11	0.15				
Wright's silk-tassel	0.30		0.08	0.11					0.11	0.11	0.09	0.11
	Railed Area				Buckman Flat				Woolsey Wash			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	0.56	0.24	0.12	0.10								
Turbinella oak	0.33	0.21	0.14	0.18								
Mountain mahogany					0.23	0.14	0.17	0.23				
Cliff-rose					0.20	0.17	0.14	0.15				
Desert ceanothus					0.30	0.16	0.14	0.18				
Utah juniper										0.08	0.10	0.16
Manzanita (*A. pungens*)									0.19	0.12	0.09	0.10

Species	Pinal Mountain Area							
	1951 Burn				Nonburn			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	0.27	0.12	0.16		0.29	0.25	0.21	
Turbinella oak	0.24	0.13	0.13	0.15	0.21	0.18	0.15	0.17
Emory oak	0.24	0.10	0.11	0.11	0.21	0,12	0.15	0.13
Mountain-mahogany	0.20	0.10	0.15		0.21	0.09	0.13	
Wright's silk-tassel	0.23	0.11	0.13	0.09	0.25	0.10	0.12	0.11
Desert ceanothus	0.19	0.08	0.09		0.25	0.12	0.13	
Manzanita (*A. pungens*)	0.20	0.13	0.09		0.15	0.12	0.13	
Manzanita (*A. Pringlei*)		0.15	0.12	0.05		0.12	0.14	0.10
Holly-leaf buck-thorn	0.31	0.10	0.11	0.11	0.34	0.11	0.12	0.14
Sugar sumac	0.30	0.14	0.21	0.14	0.36	0.16	0.16	0.17

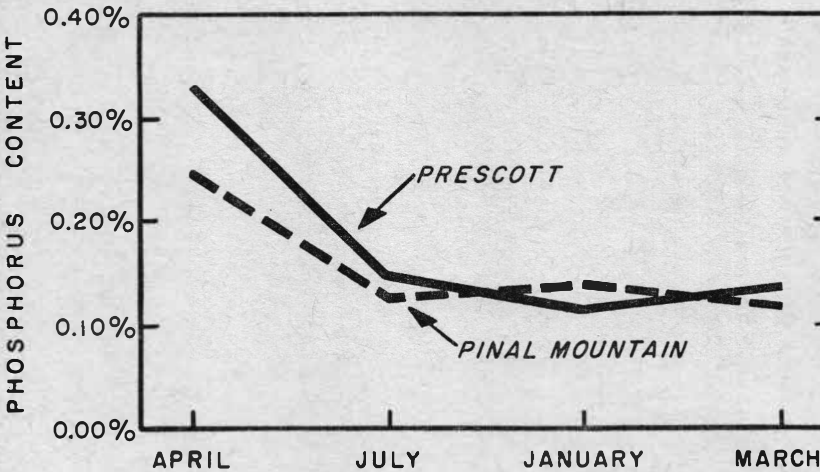

Figure 4. Seasonal phosphorus content of plants from the Prescott and Pinal Mountain areas.

browsing on it was practically nil. Sugar sumac was one of the plants with the highest moisture content, yet no use of it was found.

Phosphorus: According to Stanley (1951) phosphorus is the element most likely to be deficient for livestock in native Arizona range plants. A deficiency of phosphorus in animals retards growth, depraves appetite, greatly reduces milk production, causes irregularity in ovulation and results in improper cleaning of females when giving birth to young.

An analysis of the clippings showed a high phosphorus content during the growing period, and a gradual lowering as the plants became dormant (Figure 4 and Table 2). The difference between phosphorus content during the growing period and during the dormant period was highly significant ($t = 8.378$; 8 D.f.). On an oven-dry basis phosphorus content of actively growing browse plants from the Prescott area averaged 0.32 per cent, and those from the Pinal Mountain area averaged 0.25 per cent. This difference was signficant ($t = 2.366$; 7 D.f.)

The phosphorus content of plants during the period of growth was certainly high enough to meet minimal requirements of the deer. On both areas, however, phosphorus declined to about 0.13 per cent during the dormant period.

It is known that the phosphorus requirements of an animal are complicated by the calcium intake, the animal's age—hence growth, the drain upon the animal by reproduction and other factors. It appears, however, that during the dormant period our browse plants

TABLE 3. PROTEIN CONTENT (PER CENT) OF BROWSE SAMPLES COLLECTED ON THE PRESCOTT AND PINAL MOUNTAIN AREAS, 1954-1955.

Prescott Area

Species	Doce, 1950 Burn				Doce, 1947 Burn				Doce, Nonburn			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	17.3	8.3	4.6	5.5	17.6	8.0	6.7	6.6	16.9	8.3	6.1	6.4
Turbinella oak	20.6	7.9	8.2	6.9	15.3	9.3	8.9	7.4	16.8	8.2	7.7	7.5
Emory oak	17.0	8.2	6.4	6.8	16.5	9.0	7.3	7.9	15.0	8.1	8.4	7.3
Mountain-mahogany	18.9	10.2	7.8	8.0	16.4	10.5	7.8	8.7				
Wright's silk-tassel	14.9		6.5	6.9					9.3	7.1	6.5	6.1

Species	Railed Area				Buckman Flat				Woolsey Wash			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunk-bush	21.0	9.7	5.7	4.6								
Turbinella oak	14.0	8.1	6.8	7.1								
Mountain mahogany					11.0	9.7	8.9	9.3				
Cliff-rose					10.9	11.6	8.4	8.4				
Desert ceanothus					12.4	8.2	8.7	7.9				
Utah juniper										5.6	4.9	5.2
Manzanita (*A. pungens*)									6.0	6.2	4.7	5.5

Pinal Mountain Area

Species	1951 Burn				Nonburn			
	Apr.	July	Jan.	Mar.	Apr.	July	Jan.	Mar.
Skunkbush	12.3	6.8	5.8		12.1	6.9	8.5	
Turbinella oak	9.0	7.6	8.2	6.6	10.1	7.3	9.0	8.1
Emory oak	11.5	7.6	8.2	6.6	10.7	7.3	8.4	7.9
Mountain-mahogany	14.0	7.9	7.9		14.1	7.2	10.9	
Wright's silk-tassel	11.1	6.1	7.1	5.7	12.2	5.9	6.7	6.1
Desert ceanothus	11.8	7.9	8.6		14.3	8.2	8.8	
Manzanita (*A. pungens*)	7.9	5.6	5.7		8.1	5.5	6.6	
Manzanita (*A. Pringlei*)		5.9	5.4	3.8		4.9	5.7	5.9
Holly-leaf buck-thorn	16.7	7.1	5.0	6.8	16.3	7.3	6.5	7.3
Sugar sumac	12.5	6.4	6.1	4.0	14.0	6.0	6.0	5.7

are definitely deficient in this important element. For white-tailed deer in Pennsylvania it was found that the quantitative requirements for phosphorus in the rations were in excess of 0.25 per cent (French *et al.,* 1955). The browse plants tested were lower in phosphorus during the dormant period than dry roughage feeds commonly given to livestock. According to Morrison (1954) feeds given to cattle and sheep should contain not less than 0.17 per cent phosphorus. Only during the growing period did our browse plants come up to this standard.

Protein: Protein content of the plants was almost twice as high when they were growing as it was when they were dormant (Table 3). During the growing period protein content for all species averaged 15.1 per cent on the Prescott area, and 12.8 per cent on the Pinal Mountain area. This difference was significant (t = 2.932; 5 D.f.). During the dormant period the average for both areas was around 7 per cent (Figure 5). In other studies analysis of browse species as well as grass has shown a similar trend (Bissel *et al.,* 1955; Einarsen, 1946; Hellmers, 1940; Hagen, 1953; Stanley and Hodgson, 1938).

There was little difference in the amount of protein in the three collections (July, January and March) made during the dormant periods. There was an indication, however, that there was a decline in protein content as the current growth became older (Figure 5).

Year-long protein content was highest for mahogany and desert ceanothus, the two species considered to be the most important deer

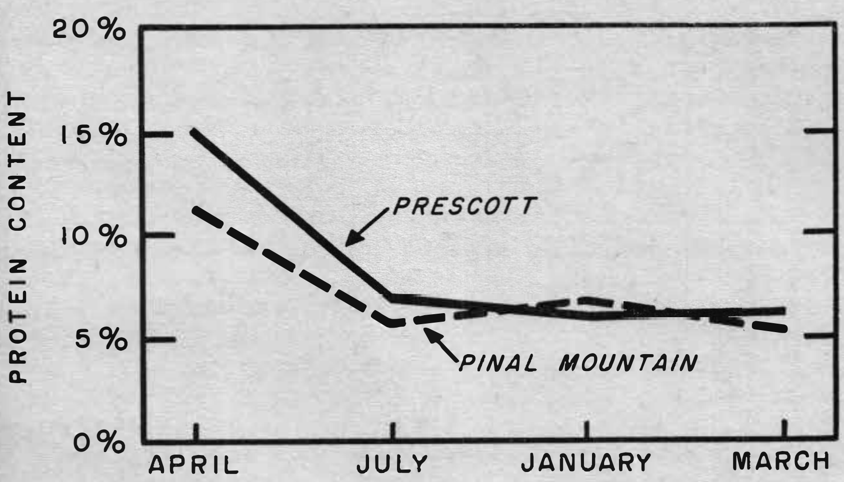

Figure 5. Seasonal protein content of plants from the Prescott and Pinal Mountain areas.

browse plants in Arizona chaparral. Both of these species have wide distribution, are abundant and are preferred foods of deer.

Cliff-rose, the most important browse plant for deer in northern Arizona, was high in protein for all collections. Protein for the four collections averaged 9.8 per cent, and at its lowest point the protein content was 8.4 per cent.

Coffee-bush, a species abundant on the desert and at lower elevations in the chaparral, had a high protein content. The peak was 21.1 per cent in the April collection, and the low was 9.4 per cent for clippings taken in January. The average was 13.5 per cent. On the desert this species is considered to be one of the most important browse plants.

Holly-leaf buck-thorn, a species constituting from 1 to 5 per cent of the shrub layer in chaparral, has a fairly high protein content. Protein of the April collections for this species was around 15 per cent, the March collections around 7 per cent and the average was around 9 per cent. Holly-leaf buck-thorn is a preferred deer food. Of 24 deer collected in Arizona chaparral, this species occurred in 13 and in 4 made up more than 10 per cent of the rumen sample by volume (McCulloch, 1955).

Species with the lowest year-round protein content were Utah juniper and the two species of manzanita. The juniper averaged 5.2 per cent protein and the manzanitas collected from three different sites averaged 5.8 per cent. Within the chaparral, Utah juniper is scarce, but at the edges of the higher plateaus in Arizona it becomes very abundant. On the Kaibab National Forest just to the north of the Grand Canyon, juniper constituted 18.2 per cent of the rumen volume of deer on winter range (Kimball and Watkins, 1951). In experimental feeding of deer, Smith (1952) found Utah juniper generally low in palatability and digestibility.

In some areas of Arizona chaparral, manzanita becomes very abundant, making up as much as half of the tall shrub crown cover. On the basis of rumen analysis and browse utilization studies, manzanita appears to be of little value to our deer, although an occasional leaf is taken. Nichol (1938) lists manzanita as low in palatability.

Throughout Arizona chaparral, turbinella oak is the most abundant shrub species. It usually makes up from 50 to 60 per cent of the shrub cover. Since this species occupies a great amount of space and inevitably has tied up in it a large amount of soil nutrients, the influence that this plant has on deer herd numbers is considerable. The overall nutritive value appears to be at the middle of the scale. Where turbinella oak and other species were tested for protein content from the same site, the oak was above 15 species, and below 12 species. In comparison with food species preferred by deer, turbinella oak has

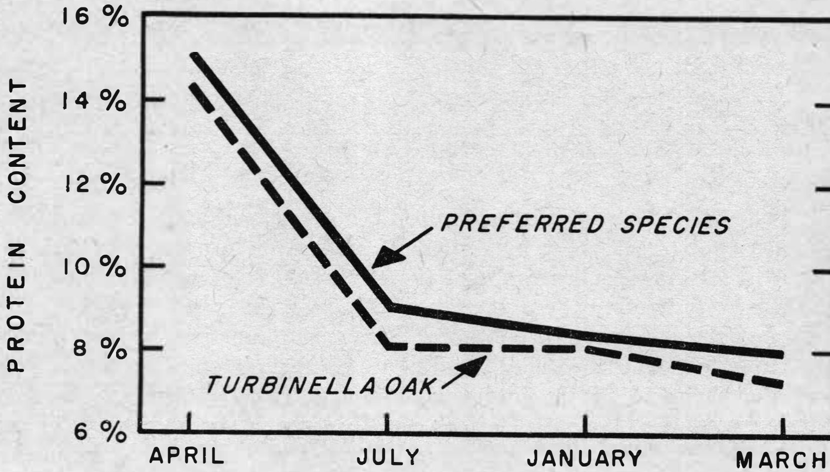

Figure 6. Average protein content of turbinella oak and five species preferred by deer from five sites.

about the same seasonal protein content (Figure 6). Analysis of rumen samples of 24 deer collected in chaparral habitat showed that six of the animals had taken turbinella oak, and in three of the animals this species occurred as the main item. The six deer that had eaten turbinella oak were all taken from one locality during the month of January. Subsequent collections of 18 deer showed none to have taken this species.

Turbinella oak and most of the other species tested showed protein content higher than the 5 per cent minimum for deer proposed by Einarsen (1946) and the 7 per cent minimum proposed by Bissell and Strong (1955). Only during the growing period did the protein level of most of the plants reach the 13 to 16 per cent determined as optimum for growth of deer by French and co-workers (1955).

As pointed out by Bissell and Strong (1955) the nutrient content of any species is only half of the story. The other half is the coefficient of digestion. Digestion trials in California with live oak (*Quercus wislizenii*), a species similar to turbinella oak, showed that deer digested only about one-third of the crude protein occurring in the material fed (Bissell *et al.,* 1955). Also of importance was the fact that deer did not appear to like the oak. Their daily intake was below normal, and the deer were in very poor condition at the end of the feeding experiments. Therefore, in spite of its abundance, turbinella oak appears to be of little value as deer food in Arizona chaparral.

Preliminary investigations indicate that under certain conditions turbinella oak may become acceptable deer food. Crown spouts of this species springing up on a burned area are palatable to deer. In the Prescott vicinity on railed and burned sites deer-use on this oak was extensive. Browsing on the sprouts began in March at the initiation of the growing season and continued into August. Analyses showed that moisture content of the plants was high during this period.

Burning in the Prescott area increased the protein content of plants. Clippings from a burn five years old had a higher protein content than the same species from an adjacent non-burned area. Both deer- and cattle-use of plants on the burn far exceeded the use of browse plants on adjacent areas. Seasonally, there was little difference between protein content of mahogany and nonpreferred species during the growing period. During the dormant period, however, mahogany definitely contained more protein (Figure 7).

Plants on an 8-year-old burn tested little if any higher in protein content than those from an adjacent nonburned area. Einarsen (1946) demonstrated that browse plants coming in on a burned area have a higher protein content, but that this diminishes as the period after the burn becomes greater. DeWitt and Derby (1955) found similar results, and further showed that differences are more pronounced with a fire of high intensity. Burns in Arizona chaparral usually occur during the month of June when relative humidity is extremely low and temperatures are high. The fires are invariably "hot."

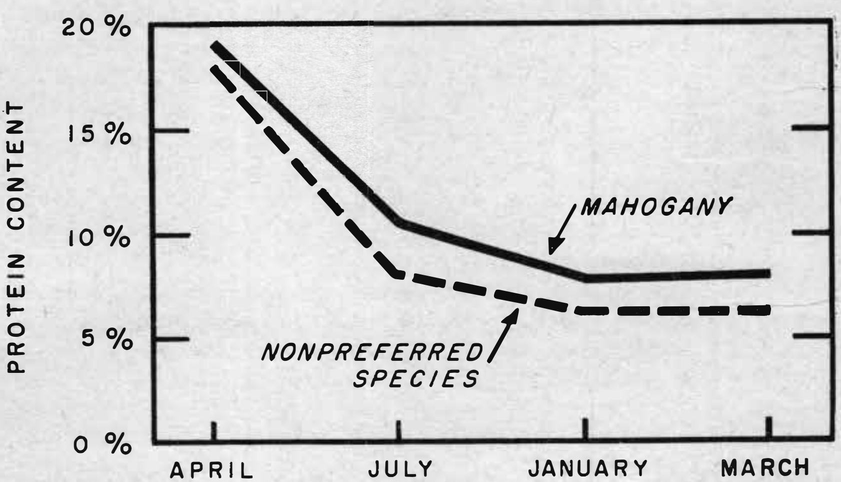

Figure 7. Protein content of mahogany and nonpreferred browse species from the Doce 1950 burn, Prescott area.

Plants from a 3-year-old burn in the Pinal Mountains contained no more protein than those from nondisturbed areas. A significance could not be mathematically demonstrated, but the over-all average protein content of plants from the burn was 7.9 per cent, whereas, protein for plants from the nonburned area averaged 8.5 per cent. It is unknown why plants in this area did not follow the same pattern as those on the Prescott area, and the trend found by almost all other investigators. It may be that the effect of the burn on the nutritive content of browse plants in the Pinal Mountain area was no longer apparent after two years. Such results have been demonstrated on some areas in California (Bissell, 1952).

Protein content of sprouts coming in on an area railed in December 1953 was higher during the growing season than that of clippings of the same species from nondisturbed sites, although the difference was not mathematically significant. During the dormant period, however, the protein content of crown sprouts from the railed area was lower than that of clippings from a nondisturbed site. As pointed out before, railing did increase tremendously the amount of annual growth produced, and considerably increased the length of the active growing season. This extended growing season produced browse highly palatable to deer at a period when browse on nondisturbed sites was dormant and dry. Most of the railed plants were turbinella oak and skunk-bush. These normally unpalatable plants were converted to a palatable condition over a long season of growth, and during this period deer-use on them was much heavier than on plants of these species occurring on nondisturbed sites. However, during the period that plants were dormant on the railed area, deer-use on turbinella oak and skunk-bush dropped to a low level in harmony with the nutritive content of the sprouts, which was no higher than that of plants from adjacent nondisturbed areas.

The average protein content of browse species from the Pinal Mountain area was lower than that for plants from the Prescott area. Although this same condition existed for most species and for most of the seasonal collections, the difference was not mathematically significant.

Deer Population Level and Nutrient Content of Browse

Locally in Arizona chaparral, deer populations vary from 20 or 30 per square mile to 4 or 5 per square mile. The high populations invariably are found in what is designated as the mixed shrub type. This type is dominated by turbinella oak, but contains a good quantity of other plants high in palatability and in nutritive value. Mahogany, desert ceanothus and holly-leaf buck-thorn make up as much as 35 per cent of the tall shrub layer. To the north and at higher elevations where the chaparral gives way to pine forests, these higher deer populations are found where good growths of cliff-rose occur.

The low population levels usually are found in what is known as the turbinella oak-skunk-bush type. There the two species, turbinella oak and skunk-bush, make up practically the entire high shrub cover. Plants of high nutritive value and palatability occur sporadically or not at all.

Taking Arizona chaparral as a unit, the deer density has been calculated at only ten per square mile (Hanson and McCulloch, 1955). The population is kept at this low level due to a shortage of herbaceous material and the occupancy of the area by dense unbroken stands of turbinella oak, skunk-bush, manzanita, sugar sumac and other nonpalatable shrubs which are low in nutritive value.

Furthermore, shrubs that are palatable and high in nutritive value are frequently overbrowsed. This overutilization reduces the vigor of the individual plant. Plants that are low in vigor cannot successfully compete and are gradually being replaced by nonpalatable, little-utilized species. Hence, the long-time trend in Arizona chaparral is for a lower carrying capacity. Annually, the overutilized palatable species produce less growth than plants with normal vigor. Since only current annual growth is high in nutritive value and of use as deer food (Aldous, 1945), less than the normal annual growth reduces the already low food supply.

To the north of the chaparral, Arizona deer occupy distinct summer and winter ranges. Their summers are spent in open ponderosa pine forests where an abundance of herbaceous plants occur. In the fall they migrate to lower elevations and south-facing slopes that are covered with cliff-rose or occasionally with mahogany. Here, taking both summer and winter ranges as a unit, deer density in recent years has climbed to as high as 26 per square mile. On the winter range, deer reach a density of 60 per square mile (Swank, 1955).

Biswell *et al.* (1952) reported that in California, mature chaparral putting out little annual growth with little herbaceous cover supported 10 to 30 deer per square mile. Areas opened by fire, containing an interspersion of fast-growing sprouts and herbaceous cover, supported from 40 to 110 deer per square mile. From their work, Biswell and co-workers concluded that "The nutritional intake of deer which have abundant herbaceous forage appears to be highest. Mature browse is of low nutrient value compared to growing herbs, except for a short spring period of rapid growth." Longhurst *et al.* (1952), working in California, state that "on practically all occupied deer ranges limitations in nutritious food regulate the numbers of deer."

In Oregon, Einarsen (1946), in a comparison of an area where protein values of browse plants were high with an area where protein values were low, found deer more abundant, healthier and larger on the former site.

In Utah, Robinette *et al.* (1952) found that winter deer mortality varied inversely with the availability of highly nutritious browse plants such as cliff-rose and mahogany.

It appears, then, that not only in Arizona, but throughout the West, deer densities are definitely controlled by the nutritive levels of available foods on their range.

SUMMARY

Food is the primary factor controlling game population levels. A low nutritive intake depresses the rate of production and increases the rate of mortality.

Shrub species common in Arizona chaparral were tested for moisture, phosphorus and crude protein content. Analyses were made of plants from burned sites, a railed site and nondisturbed sites. Collections were taken at four different stages of growth.

The plants were highest in moisture, phosphorus and protein during the growing period. Moisture and nutritive content of plants from recently disturbed sites in the Prescott area attained a higher level during the growing period, and this level remained higher over a longer period than that of identical species from nondisturbed sites. Plants on the disturbed sites also received heavier use. Disturbance had no significant effect on plants from the Pinal Mountain area. Browse plants preferred by deer had a higher moisture, phosphorus and protein content during the dormant period than those used little or not at all.

The phosphorus level of Arizona chaparral browse plants appears to be satisfactory during the period of active growth. During the dormant period, however, the plants contain less than the minimum amount of phosphorus recommended for deer and livestock rations.

Turbinella oak, skunk-bush, manzanita and other species usually constituting 70 per cent or more of the tall shrub cover of Arizona chaparral are low in palatability and nutritive value, and of little use as deer food. Crown sprouts of turbinella oak and skunk-bush coming in on recently burned and railed areas were highly palatable during the growing period.

In Arizona chaparral, deer population levels are lowest where few plants of the most nutritious and highly palatable species occur. Deer

population levels in Arizona are highest where deer spend the summer in open ponderosa pine forests with an abundant understory of herbaceous material and spend the winter at a lower elevation where good growths of cliff-rose, mahogany and other palatable species occur.

Results of this study and work by other investigators indicate that not only in Arizona, but throughout the West, deer densities are definitely controlled by the nutritive levels of available food on their range.

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DISCUSSION

MODERATOR WHITLOCK: Gentlemen, we are running a bit behind schedule and the chairman and I thought that we had better keep as near as we could to the schedule. I probably should suspend the rules here and give the chairman a chance to talk because I think that he, among all of the members, is well qualified to discuss this particular work. He is a specialist in nutrition and he is also from the West and I think therefore that he could comment intelligently on the work here.

Does anyone have any comments on this material?

MR. GIBERT HUNTER [Colorado]: I would like to compliment the doctor on his paper. I notice that he brought out a relationship there between the productivity of deer in relation to the range. However, I think that there is a word of caution in this. For example, in the Echo Park region of Colorado we have had a two-deer season since 1948. In those particular game management units we have killed around 47,000 deer. However, now we are faced with the fact that even though we are bringing that herd into line as compared to the range that our reproductive rate is going up and that each year since 1948, with the exception of one, we have been harvesting from six to seven deer each year on those particular units. Therefore, I wonder if we have the answer.

It seems as if, when we knock down our deer herds, up goes the reproductive rate.

MODERATOR WHITLOCK: I suppose that this might bring up the biological principle that, frequently, reproductive rates are stimulated by reduction of population. You cannot necessarily associate it with a simple thing. I am not sure that all of these answers are known.

DR. SWANK: I think that we are running across the same thing in Arizona. I think that we are going to have to have a little different concept in wildlife management, even in big game species, and that is that deer are an annual crop. In other words, productivity is dependent, perhaps, on the material that the deer are getting on the summer range and you have a rapid turnover. Even in deer management I think that we will finally come to the concept that we had better harvest our deer as an annual crop rather than extend the build-up over several years.

DEER NUTRITION AND POPULATION DYNAMICS IN THE NORTH COAST RANGE OF CALIFORNIA[1]

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This report concerns the nutrition and population dynamics of Columbian black-tailed deer (*Odocoileus hemionus columbianus* [Richardson]) inhabiting the hard brush or chaparral regions of northern California, with special reference to the middle Coast Range in Lake County. The study area lies just west of Lakeport, between the elevations of 1500 and 2500 feet. In this region the chaparral consists of a dense growth of shrubs between 5 and 20 feet tall, when undisturbed, broken into north- and south-facing slope associations. South-facing slopes are covered with an association of relatively short-statured shrubs dominated by chamise (*Adenostema fasciculatum*); the cover on north-facing slopes is taller and is dominated by interior live-oak (*Quercus wislizenii*). These, and most of the woody species associated with them, typically sprout from the large root-crown after burning (Sampson, 1944). The crown-sprouts form a preferred food of the deer, and, in the past, many fires were deliberately set to improve deer forage. Fires still occur, because the plants, especially on the south exposures, become dry and inflammable during the long summer and fall dry season. These uncontrolled fires are destructive to watershed values and are extremely difficult to extinguish, because of the impenetrability of the brush.

The chaparral is used chiefly for watershed protection and deer hunting. It has been the goal of management to improve it for the production and hunting of deer, and to make fire easier to control, all without damaging the watershed capabilities of the site. A considerable body of information on techniques has been accumulated (Biswell *et al.*, 1952; Taber, 1953) and numerous areas have been treated; this work continues. The current plan of management is to reduce the shrubs in density and height on about half the area by controlled fire or mechanical means and to seed the intervening area with herbaceous plants.

Chaparral managed in this way gives the impression of a "woodland of shrubs"; that is, each shrub is to some extent separated from its neighbors by an interval of ground covered by herbaceous vegetation. Therefore the term *shrubland* is applied to it. In previous publications it has been called *opened brush* (cf. Biswell *et al.*, 1952). The unmanaged chaparral is properly termed *climax chamise chapar-*

[1]Contribution from Federal Aid in Wildlife Restoration Project W-31-R and the Museum of Vertebrate Zoology, University of California.

ral (south slopes) and *mixed* or *mesic chaparral* (north slopes) (Cooper, 1922) and will be termed simply *chaparral* for convenience here.

The present report is an assessment of how converting chaparral to shrubland affects the resident deer populations. This includes studies made on deer populations inhabiting shrubland as well as the unmanaged control, that is, undisturbed chaparral.

The two range-types under study were chosen to be as nearly alike as possible, except for the program of management. The topography is one of low, steep-sided, rounded ridges, drained by intermittent streams. The principal soil series is *Maymen,* in which the profile is usually only a few inches deep, formed on sandstone and shale. The climate is Mediterranean, with a wet season extending from about November to March, during which almost all of the average of 28 or 30 inches of rain falls. Snow is uncommon. The dry season, extending from July to October, is moderately hot, often over 90 degrees F. in the afternoon, with low humidity. The annual grasses are able to grow during the wet season, but most forbs and shrubs requiring higher temperatures make their main growth in late March and April. During the dry season there is little growth, although shrubs may show re-growth if heavily browsed. Surface water is well distributed and persists through the dry season in adequate amounts.

The study was carried on from 1949 to 1955. It was materially helped by many members of the California Department of Fish and Game and the University of California at Berkeley. Notable among the former were Howard Leach, who identified plant species present in rumen samples and Harold Bissell, who made crude protein determinations of forage samples both under Federal Aid in Wildlife Restoration Project W-25-R. From the University, aid and encouragement were given especially by H. H. Biswell, Project Leader; A. M. Schultz; and A. Starker Leopold. Raymond F. Dasmann, now of Humboldt State College, Arcata, was intimately associated with much of the field work.

METHODS

Measurements of vegetation: Species abundance on each cover-type was determined by means of *point intercept lines.* These lines were run along compass-bearings by teams of two men. Each team was equipped with a 50-foot cord, marked at 3-foot intervals and weighted on one end. The cord was thrown ahead in the correct direction, over the shrubs, and tightened so as to be as nearly parallel to the slope as possible. Then a weighted string was dropped and the first hit was recorded for each mark in succession (Bauer, 1943). Every time a shrub was hit, its average diameter was recorded. In this way the frequency index of each species and also the number of individuals per unit area could be determined.

The amount of forage provided by each species was calculated by establishing the yield per unit of surface area for each growth-form and relating this to the amount of available surface area per square mile.

The quality of the forage provided by each species, seasonally, was determined by systematic sampling (simulating deer-use) followed by laboratory analysis (Bissell and Strong, 1955).

Measurements of deer, their food habits and populations: Deer weights and measurements were obtained for collected deer, trapped deer, and deer shot by hunters. The age of each individual was ascertained by the state of tooth eruption and wear (Severinghaus, 1949; Moreland, 1952).

Deer food-habits were studied principally through examination of rumen-content samples obtained from deer collected at every season. Each sample amounted to about one pint, and was taken after the rumen contents were thoroughly mixed. Formalin (10 per cent) was used as a preservative. The analysis was by volume.

Deer population density was measured by the pellet-groups, Lincoln Index, sample-area-count and total count methods (Dasmann and Taber, 1955).

Deer population structure was measured by means of herd composition counts (Dasmann and Taber, 1956-a).

Movement was studied through the observation of tagged deer (Dasmann, 1953; Dasmann and Taber, 1956-b).

Reproduction was studied through the examination of collected deer (Taber, 1952; Taber and Dasmann, 1956) and the observation of live deer in the field.

Availability of forage: Even though a plant is present, its foliage may be unavailable because it is too high for deer to reach, because it is protected by dense intervening branches, or because deer do not feed in that area at that season. In the present study, only the first of these factors was measured. Forage beyond about four feet from the ground level is seldom taken, in this region, so four feet can be considered the limit of availability. In some places deer often rear on their hind legs to reach choice browse but this is rare among the deer of the present study except when they are feeding in orchards.

FINDINGS

Available forage—herbaceous: The herbaceous cover in this area consists mainly of annual grasses and both annual and perennial forbs. The annuals, on the whole, are those commonly listed in the California annual range type (Sampson, 1944). The usual species used for artificial seeding is soft chess (*Bromus mollis*) but once an opening is established other plants quickly invade. The important perennial forbs are more strictly plants of the mountains—bedstraw (*Galium* sp.), American vetch (*Vicia americana*) and soap plant (*Chlorogallum* sp.).

Comparing shrubland and chaparral, herbaceous vegetation differs in distribution, density and amount. About 30 per cent of the ground in shrubland and 5 per cent in chaparral is in herbaceous cover. The density of herbaceous vegetation is much greater in the shrubland, presumably because of less shading—herbaceous density in shrubland averages about 17 per cent while that in chaparral averages about 6 per cent. As a result the total amount of herbaceous forage (oven-dry weight) per square mile in March in the shrubland is about 55,000 pounds, while the comparable value for chaparral is about 3,000 pounds; these values are equal to 86 and 5 pounds per acre respectively.

Available forage—woody: The shrubs which furnish most of the browse are: chamise, interior live-oak; scrub oak (*Quercus dumosa*), poison oak (*Rhus diversiloba*), deerbrush (*Ceanothus integerrimus*), Toyon (*Photinia arbutifolia*), California laurel (*Umbellularia californica*), yerba santa (*Eriodictyon californicum*) and western mountain mahogany (*Cercocarpus betuloides*). These species are found both in shrubland and chaparral, but their growth-form is often different in the two places. In chaparral the plants occur as tall shrubs or small trees, especially scrub oak, deer-brush, laurel and mahogany, with most of their foliage beyond the reach of deer. In shrubland, on the other hand, the plants have been burned or the tops broken off, so that they sprout from the base; deer use keeps these plants low and rounded, so that the foliage is available. Plants in this form are, however, liable to be damaged by over use.

Table 1 shows the ground covered by each of these species in representative areas of shrubland and chaparral and the total amount of available forage produced annually by each on one square mile; 324,160 pounds in shrubland and 115,960 in chaparral. As these figures show, some preferred shrubs may be abundant but yield relatively little available forage because of their height.

Annual diet: Deer show marked seasonal forage preferences. Often these may be traced to species differences in the phenology of growth, or in availability. When different range-types are compared, as is the case here, the effects of availability are especially striking, since certain preferred foods, which are heavily taken on one area, may be largely unavailable on another.

Herbaceous vegetation apparently is a favorite winter and spring food in this region. In shrubland, where there is a good supply, it constitutes 45 per cent of the annual diet; in chaparral, where there is only a small amount, it constitutes only 10 per cent. This is shown in Figure 1, where the average monthly diet for the two range-types are graphed; these data were derived from rumen analyses.

Considering grasses and forbs separately, it may be seen that on both range types the grasses tend to be taken in winter and the forbs in spring. This presumably is due to the fact that the grasses have attained their full growth by the end of winter, whereas many forbs make their major growth in the spring. The deer, then, take either form when it is in its period of rapid growth.

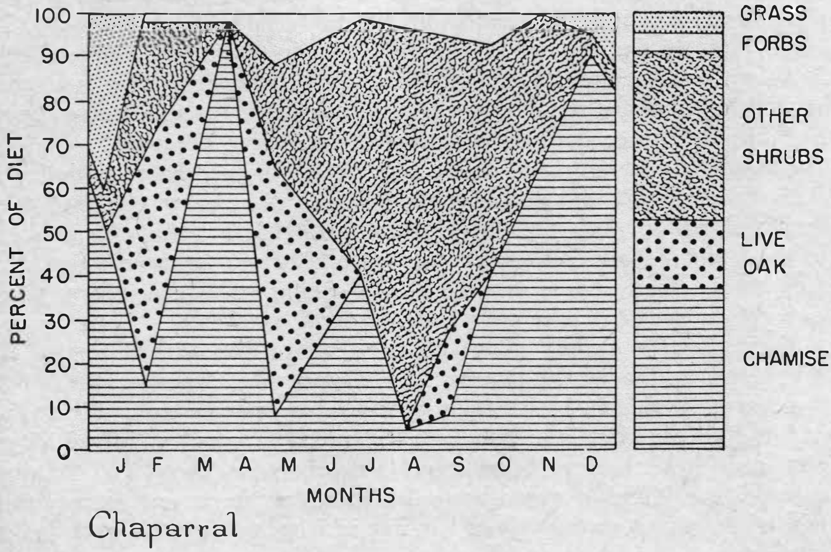
Woody plants supply about 55 per cent of the annual forage in shrubland and over 90 per cent in chaparral. Chamise, the most important species on both ranges, is taken at every season. Live oak, which, like chamise, is an abundant plant, is browsed mainly during May and June, before its leathery leaves become too tough. It also supplies considerable quantities of acorns during certain years; the winter and fall consumption of live oak in Figure 1 is made up largely of acorns.

The remainder of the forage shrubs—scrub oak, poison oak, deer-brush, toyon, laurel, yerba santa and mahogany—have been lumped for simplicity in Figure 1 as *other shrubs*. Except for yerba santa, which is taken principally in the spring, these supply the bulk of the forage during the dry season.

Plane of nutrition: The findings on diet are of interest in themselves; they may also be translated into nutritional terms.

TABLE 1. PRINCIPAL FOOD-PRODUCING SHRUBS: ABUNDANCE AND YIELD OF AVAILABLE FORAGE PER SQUARE MILE (IN POUNDS, OVEN-DRY).

Species	Percent of ground covered by each species		Amount of available forage per species	
	Shrubland	Chaparral	Shrubland	Chaparral
Chamise	15.0	20.2	209,536	37,300
Interior live oak	8.5	17.1	16,960	35,900
Scrub oak	2.2	11.3	36,160	27,200
Poison oak	2.9	5.0	13,440	6,150
Deerbrush	1.4	6.2	1,472	1,540
Toyon	2.0	0.6	14,720	2,160
California laurel	0.3	2.0	2,944	1,280
Yerba santa	2.4	0.3	28,416	3,580
Western mountain mahogany	0.5	1.8	512	850
Total	35.2	64.5	324,160	115,960



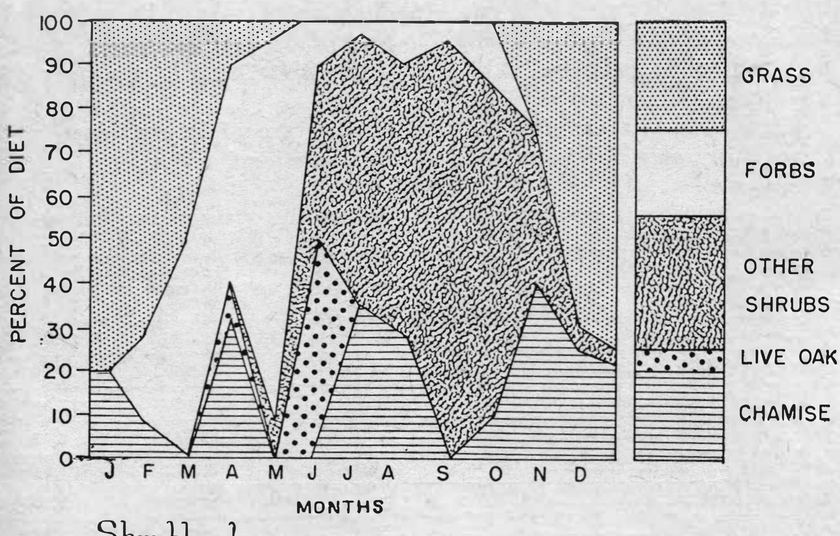


Figure 1. Annual diet of deer, by month, on chaparral and shrubland range.

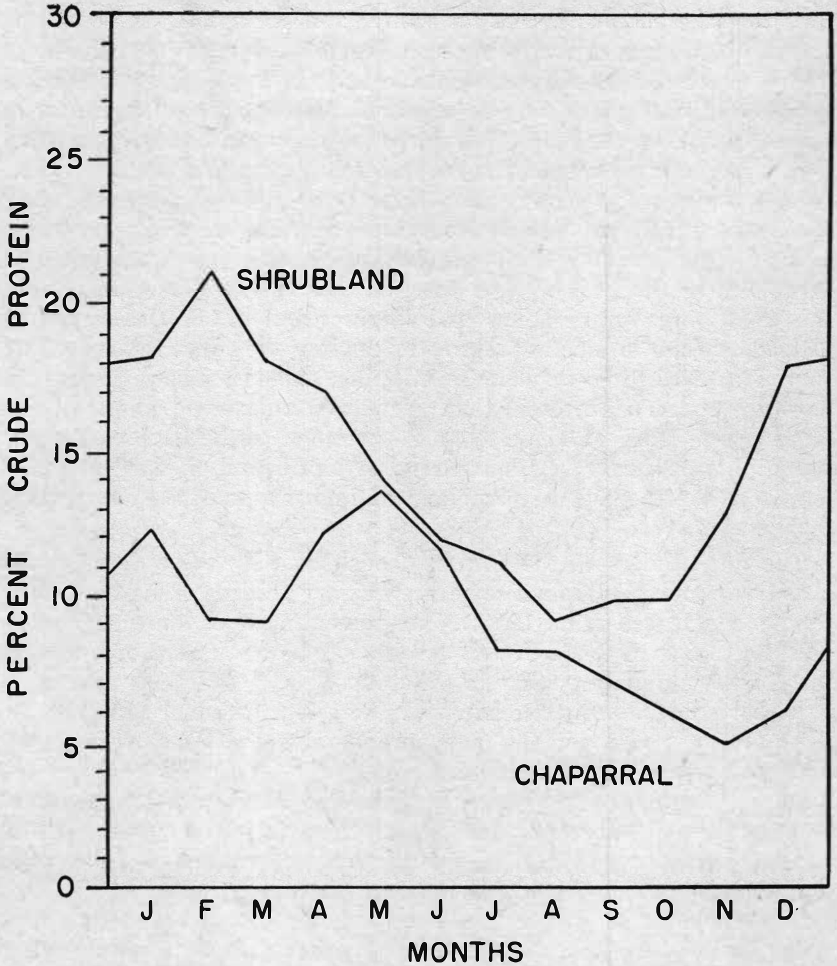


Figure 2. March of crude protein in the annual diets of deer on chaparral and shrubland range.

Figure 2 shows the march of crude protein in the annual diet of deer in shrubland and chaparral, arrived at by means of rumen analyses (Figure 1) and the monthly clipping and analysis of forage samples. The average per cent of crude protein (dry weight basis) in the deer diet on each range-type is: shrubland—14 per cent; and chaparral—9 per cent.

The reasons for the superiority of shrubland over chaparral in this respect are: 1. the shrubland furnishes about 18 times as much highly nutritious herbaceous forage for winter and spring; 2. the shrubs of the shrubland are kept within reach (by browsing), so that the more highly preferred species are available and the more highly preferred portions of each plant may be selected. An example of the latter is the stripping of chamise. This plant, after being burned, sends up long straight leaders from the root-crown. During the summer, when forage values fall, the deer strip these between their incisors, eating the leaves, which are high in food value, and leaving the stem, which is low in food value. Stripping is possible only when the plant is kept low; in the heavy brush the deer generally browse chamise in the usual way, taking stems and leaves together. 3. Heavy use of hedged shrubs promotes regrowth during the dry season. This regrowth, according to chamise clipping experiments, is higher in moisture and crude protein than growth on unbrowsed plants at the same season. All of these factors—presence of herbaceous forage, availability of shrub growth and re-growth of heavily hedged plants—tend to make the diet in shrubland of higher nutritive quality than that in chaparral.

The digestibility of the various foods taken by these deer is still largely unknown, although some preliminary feeding trials have been conducted (Bissell *et al.* 1955). Our present state of knowledge compels acceptance of crude protein level as the best standard of comparison for the nutritive quality of different diets.

In both shrubland and chaparral there is a seasonal variation in the march of protein in the diet; in general the wet season is one of high quality and the dry season one of low.

In the chaparral the winter diet, consisting mainly of browse, runs between 9 and 12 per cent protein. In the spring it increases to 12-14 per cent and then rapidly falls, as the browse becomes dormant with dry weather, to 5 to 7 per cent in the summer and fall.

In shrubland the winter diet, consisting mainly of herbaceous forage, runs between 18 and 21 per cent, roughly twice the quality of the diet in the heavy brush. In the spring it decreases to 12-17 per cent, about the same as the heavy brush. In the summer it runs from 9 to 11 per cent. The fall level of crude protein, instead of continuing downward as in the case of the heavy brush, turns up as the first rains cause germination and growth of the annual grasses, which are eaten by the deer as soon as they appear.

To sum up the findings on forage production, we have seen that shrubland produces more forage than chaparral (Table 1) and also that the average deer diet on shrubland is of higher nutritive quality than that on chaparral (Figure 2).

Deer populations: Deer population density in shrubland and chaparral at different seasons of the year is shown in Figure 3. The shrubland supports over twice as many deer at any season than the chaparral—about 60 per square mile in December, for example, to about 25 for chaparral. This is presumably a reflection of the fact that food production on shrubland is considerably greater than that on chaparral.

The gain in population at fawning time is proportionally greater on shrubland, as may also be seen in Figure 3. The does are not only more numerous, but also more productive. Among does over two years old, those of the shrubland produce about 1.65 fawns apiece, on the average, while those in the chaparral produce 0.77. This is presumably because of the superior quality of forage on the shrubland, which results in a higher ovulation rate among the does there (Hart and Miller, 1937).

As might be expected, the weight of individual deer also shows a difference between the two range types. Live weights of 82 bucks

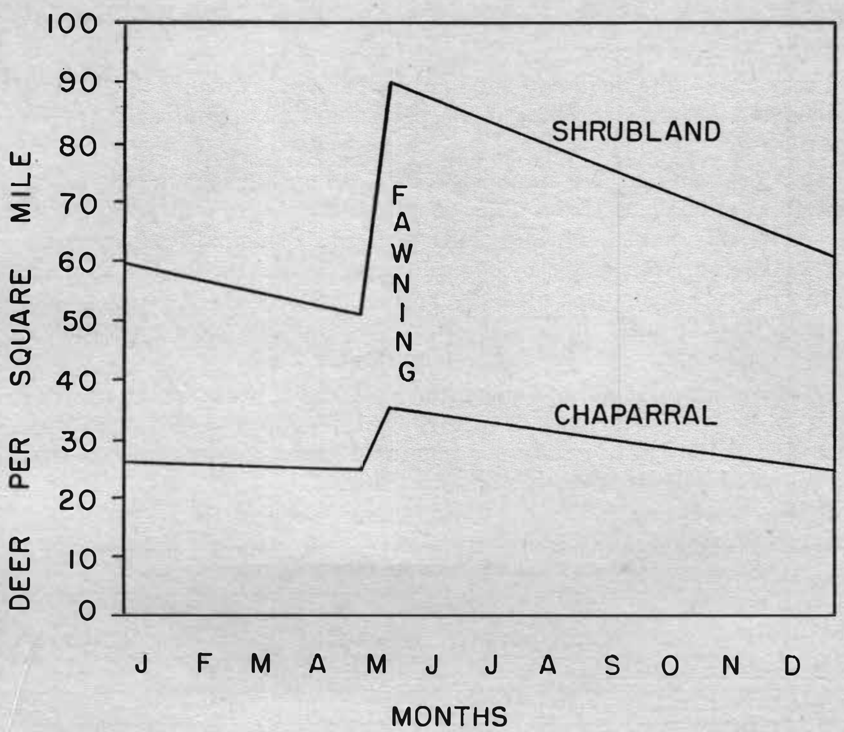


Figure 3. Deer population density through the year on chaparral and shrubland range.

three age classes from shrubland and chaparral are shown in Table 2. Although there is overlap in the extremes, the mean weights within each age class are higher for the shrubland in every case.

Present yield: Under present law (1955), only bucks bearing forked antlers are legal game. In this area a buck is at least 27 months old when he enters his first hunting season as a target. The kill per square mile depends on the number of bucks, the hunting conditions and the number of hunters. In general, shrubland is more easily hunted than chaparral, because the deer may either be seen in the open, or driven into the open with dogs. The kill on shrubland thus tends to be proportionally higher; in addition there are more bucks on shrubland because of the greater deer density there. On the average there are about 11 bucks per square mile of shrubland before the hunting season, and about 4 or 5 of these are killed. In chaparral there are about 6 or 7 bucks per square mile and 1 or 2 of them are killed. These kill values include crippling losses, which amount to about 40 per cent of the take-home kill. The buck population in the chaparral tends to include many old bucks which are almost invulnerable in the heavy cover.

Translated into field-dressed (= paunch-out) weight, the kill on shrubland amounts to 397 pounds per square mile, compared to 139 pounds for the chaparral.

It is obvious that the annual loss due to hunting is a small part of the total annual loss from either population. Since both populations are relatively stable, loss must balance gain. Principal losses are due to weakening, apparently by low nutrient intake during the summer and fall, and occur most strongly among fawns and old deer. In the shrubland, for every buck shot, 10 other deer die, mostly of starvation. In the chaparral the equivalent ratio is 1:21.

A more adequate harvest should be made, both to lessen the wastage and to prevent over use of the range. It appears that necessary changes in the hunting laws are imminent and antlerless deer as well as antlered will be taken in the near future.

TABLE 2. LIVE WEIGHT OF ADULT BUCKS TAKEN IN AUGUST AND SEPTEMBER FROM CHAPARRAL AND SHRUBLAND.

	Chaparral		Shrubland	
	Mean weight ($l_1 - l_2 = .10$)	Sample size	Mean weight ($l_1 - l_2 = .10$)	Sample size
Two-year-old	86 ± 6	19	98 ± 8	14
Three-year-old	112 ± 10	10	122	3
Four years and older	130 ± 7	24	140 ± 12	12

The potential yield: It is not possible to forecast the changes which will take place in population structure under an any-deer harvest, or what the kill will consist of. But it is possible to get a rough idea of the increase over present yield by assuming a straight 20 per cent kill of the present July population. This is done in Table 3. The calculated yield (field weight) is 861 pounds per square mile for shrubland and 378 pounds per square mile for chaparral.

These values for potential yield may be compared to those given by Westerskov for actual yields in Denmark under a full harvest (702 pounds per square mile), actual yields in Michigan under a buck law (428 pounds per square mile) and potential yield in Michigan under a full harvest (700 pounds per square mile) (Westerskov, 1951). There is a remarkable similarity between actual yields under the buck law in shrubland and in Michigan (397 : 428) and the

TABLE 3. YIELD UNDER AN ANY-DEER LAW.*

Sex	Age Class	Kill per sq. mile	Field dressed weight**	Pounds per square mile
A. Shrubland.				
♂	4 yr. +	0.87	111	97
♂	3 yr.	0.36	98	35
♂	2 yr.	0.96	80	77
♂	1 yr.	1.12	51	57
♀	3 yr. +	3.85	67	265
♀	2 yr.	1.41	61	86
♀	1 yr.	1.71	49	84
♂ & ♀	Fawns	6.56	24	160
	Total	16.8		861
B. Chaparral				
♂	4 yr. +	0.69	103	71
♂	3 yr.	0.24	90	22
♂	2 yr.	0.38	70	27
♂	1 yr.	0.48	51	24
♀	3 yr. +	2.13	67	143
♀	2 yr.	0.52	61	32
♀	1 yr.	0.56	49	27
♂ & ♀	Fawns	1.32	24	32
	Total	6.3		378

*A hypothetical harvest amounting to 20 per cent oft he present July population.
**Weights for antlerless deer are listed as the same on both range types because weight records are too few to consider separately.

TABLE 4. ACTUAL AND POTENTIAL YIELDS FOR CALIFORNIA, MICHIGAN* AND DENMARK*, IN POUNDS (FIELD-DRESSED) PER SQUARE MILE.

Range	Kill under the buck law	Kill under a full harvest
Chaparral	139	378**
Shrubland	397	861**
Michigan	428	700
Denmark		702

*After Westerskov, 1951.
**From Table 3.

yields under a full harvest, potential for shrubland and actual for Denmark (861 : 702). It might be fruitful to extend this type of comparison to other ranges.

Discussion

Given an area of chaparral under present conditions, management for deer could take two forms—management of the cover or management of the harvest. Management of the cover to convert the chaparral to shrubland will, according to the findings of this study, improve deer forage in both quantity and quality. This will result in an increase in the density and productivity of the deer population. Caution, however, must be exercised to prevent the deer from killing out certain species by overuse.

Under the buck law this sort of management has been found to increase the yield to about three times the level in the chaparral.

Under a full harvest, which must include the shooting of antlerless deer, it has been calculated that the increase in yield will also be about three times the present level in the chaparral under the buck law. Thus we have two ways of tripling the yield—an expensive and laborious management of the vegetation or a relatively simple change in the system of harvest.

Assuming that cover-management continues, and a greater and greater area of chaparral is converted to shrubland, an even more important reason for a full harvest will soon arise. One of the principal characteristics of converted areas, as has been pointed out, is that shrubs which previously had most of their foliage beyond the reach of deer now are reduced to a dense, low form, available for browsing. Studies of shrubland have not been carried out over a long enough period of time for the determination of the optimum browsing pressure necessary to keep the shrubs in this state without killing them out or allowing them to grow beyond reach. But it may confidently be stated that if no herd control at all is practiced, as is the case at present, preferred shrubs will be killed from over-use.

Population control, then, is a necessary corollary to chaparral cover management if the range is not to be damaged. The details of the most satisfactory plan of population control will best be developed through experimentation.

SUMMARY

Two types of California deer range were studied—*chaparral* and former chaparral which had been managed by burning and seeding—called *shrubland.* The two differed in production of available forage, and in deer populations, as shown below:

Available Forage (pounds per acre)	Chaparral	Shrubland
Herbaceous	5	86
Woody	181	506
Average Protein Level of diet	9	14
Deer Density (Per square mile in December	25	60
Live Weight of Bucks 2 year old	86	98
3 year old	112	122
4 year and older	130	140
Yield Per Square Mile (in Pounds, dressed) Under buck law	139	397
*Under full harvest	378	861

*Based on an assumed kill of 20 per cent of present July population.

The differences between the two deer populations are presumed to be due principally to the differences in the quantity and quality of available forage.

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DISCUSSION

MODERATOR WHITLOCK: Dr. Taber has presented some figures which I think can be duplicated in other parts of the country, not under the exact circumstances, of course. However, it is general knowledge among all of the game biologists in the country that food supply is the important thing in the production of deer. There are other influences which we do not understand as yet, but it alone probably is the most important thing governing the size of our deer herds.

As he pointed out, the big question is, what are we going to do about it? We have the know-how as far as production is concerned but I don't think that we have the know-how as far as the other criteria are concerned. Does anyone have any comments?

MR. SELKE [Minnesota]: I liked the paper very much. I wondered if you had considered the comparative cost of chaparral and of shrubland per pound of deer?

MR. TABER: So far we have done this on an experimental basis but we have not made a cost accounting.

MODERATOR WHITLOCK: That, of course, is a good question for everyone realizes that when you start to add dollars and cents in the game management phase that you generally run into trouble. It is getting back to the same old question, what is a deer worth? I think that is something that is hard to discuss.

CHAIRMAN BISSELL: I would like to say that each of the preceding speakers have made mention of one item that I consider very important and that is this moisture content of the browse being studied. It was mentioned from the viewpoint of its effect on enhancing the digestibility of food. I think that this is something that should be given consideration, the protein intake as to the food at various times of the year.

MR. BRANDBORG [Washington, D. C.]: I would like to know what effect the things that you described here had on the water run-off of your experimental area.

MR. TABER: I did not keep any figures on that but good ground cover vegetation seems to give a better soil protection and growth control cover than was ordinarily found in the arid chaparral.

AN EPIZOOTIC IN DEER IN MICHIGAN

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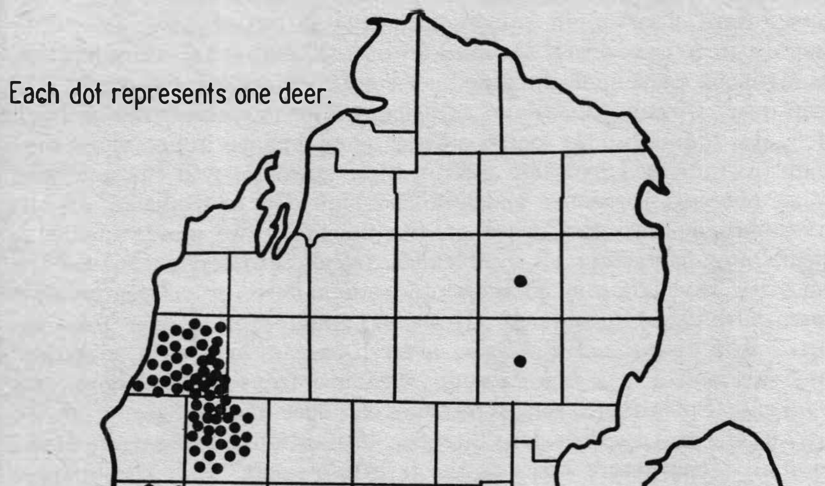
A white-tailed deer mortality, epizootic in nature, occurred in the Lower Peninsula of Michigan in the late summer and fall of 1955. Losses were observed in varying numbers in ten counties extending roughly in a belt across the middle of the peninsula. Conservation Department personnel examined or confirmed reports on about 112 dead deer. Circumstances and additional reports of carcasses or fresh skeletons found by lay persons lead us to believe many more died than are indicated by these figures. The epizootic was characterized by an abrupt appearance and localized high deer mortalities. In our investigations into the cause of the mortality we were unable to isolate any bacterium of significance from carcasses, reproduce the condition in laboratory animals other than deer, or relate the deer losses with toxic substances. However, when captive deer were injected with tissue material from a fresh carcass of a wild, sick deer they succumbed in a few days, indicating a transmittable agent was involved. Subsequent serial passages in deer by the use of tissue suspensions and bacteria-free filtrates substantiated this evidence and pointed strongly to a virus as the infective agent. It is the purpose of this paper to describe the epizootic as it occurred in Michigan, our investigations of its cause, and the results of the investigations to date.

Figure 1 shows the distribution of the dead deer for which we have reliable records. The numbers of deer represented are necessarily arbitrary because it was impossible for Conservation Department personnel to investigate and confirm all reports received because of distances involved, incomplete information on location, or the state of decomposition of carcasses. While the numbers are arbitrary, the occurrence of the epizootic in each county represented was authenticated by at least a single carcass that showed typical pathological lesions. Although no large-scale search was made to determine the over-all deer loss, it must have been considerable on the basis of the small fraction of the total area that was searched. Searches were for the most part conducted in the places where dead deer were first discovered by chance. For this reason it is possible that the discontinuity in the pattern of distribution as shown in Figure 1 does not reflect the true situation but is, instead, the result of incomplete information on the deer mortality. A number of skeletons, some with antlers in the velvet, were unofficially reported in intervening counties. The numbers of sick and dead deer for which we have reliable

Fig. 1. DISTRIBUTION OF DEAD DEER
FALL, 1955



records vary from a single deer per county to more than 35 in one township. In one of the areas hardest hit, 11 carcasses were found along about one and one-half miles of stream course, and three miles away nine carcasses were found along about one mile of a second stream. Carcasses were found in various states of preservation, ranging from very fresh to an advanced state of decomposition, indicating that the epizootic continued in a given area over a period of time.

The first indication of an unusual deer mortality came to our attention when fishermen discovered sick and dead deer along streams on the west side of the state on the week-end of September 3 and 4. Reports of dead deer in other counties followed rapidly. The presence of fresh skeletons indicated that the mortality may have begun in some localities two or three weeks earlier. The epizootic appeared to reach the peak in September and continued on a diminishing scale to the middle of November. Deer of either sex and all ages succumbed. The mortality appeared not to be correlated with high deer populations, particular forest cover types, or the continuity of large tracts of deer habitat. Mortality occurred also in two eastern counties, which are predominantly agricultural areas in which deer habitat is restricted to relatively small "islands" of wooded and brushy submarginal land separated from the extensive deer range of northern Michigan. Curiously, the dead deer almost invariably were found near water, either streams, lakes, or drainage ditches; more so than would be expected from the natural distribution of the deer or that would result from our manner of searching.

SYMPTOMS AND PATHOLOGICAL FINDINGS

There was little opportunity to observe symptoms in sick deer because only four were found while yet alive. One, a fawn, jumped from a thicket, ran stumblingly for about 50 feet and fell down where we easily caught it with our hands. Once restrained it made little effort to break away. It died about 20 minutes after its capture. The other three deer that were caught alive showed little that was striking in the way of symptoms other than general weakness that was indicated by a staggering gait or inability to stand. They died also within three or four hours after they were captured. It was apparent that practically all of the deer died from an acute condition. With the exception of one that will be described later in this paper, they were invariably in excellent flesh. From the undisturbed condition of the ground in the vicinity of the carcasses it was evident they died without struggle.

Examinations of dead deer revealed in some individuals a bluish coloration of the tongue and mucosa of the lips. Occasionally, there were numerous small hemorrhages on the gums. Frequently, the eyes were bloodshot and the membranes about the eyes reddened and swollen. Internally, the most conspicuous autopsy finding consisted of hemorrhages throughout most of the body. Sometimes there were bloody patches and accumulations of blood in the tissues directly under the skin and in the muscles about the chest and flank regions and occasionally along the neck and back. Hemorrhages were found most consistently in the internal organs in the form of large hemorrhagic patches and numerous small hemorrhages over the outer wall of the rumen and the abomasum. The linings of the rumen, abomasum, and the small intestine generally were studded with hemorrhages varying from ones well defined and pin-point in size to those more diffuse and several millimeters across. In a few instances free blood was observed in the lumen of the intestine in the areas of severe hemorrhagic involvement of the mucosa. Occasionally, the wall of the rumen and the abomasum was edematous, increasing the thickness to two or three times that of the normal condition. In some deer there was a pint to a quart of fluid, frequently bloody, in the chest cavity as well as an excess of fluid in the pericardial sac. Occasionally, there were numerous hemorrhages on the heart. The lungs were generally reddened and congested. The lining of the trachea was usually intensely red as result of congestion and rupture of the small blood vessels. No erosions were observed on the tongue or the oral mucosa. Liver changes were not pronounced other than for a few scattered hemorrhages. In rare instances there were small hemorrhages in the lining of the urinary bladder. The kidneys showed little apparent change outside of possible congestion. The spleen appeared somewhat thicker than normal and the substance quite pasty, whereas the organ is usually quite fibrous as observed under normal conditions. The urine in the bladder was generally of normal color. In most instances the stomach contents were of near normal color, consistency, and amount.

An exception to the general picture was one deer that we believe warrants particular note. A fawn was discovered alive in an area in which eight dead deer were found at nearly the same time. The fawn was extremely weak, emaciated and barely alive. Autopsy revealed extensive degenerative changes in the large muscles of the shoulders, and the rear legs as evidenced by grayish-white streaks and mottlings through the muscle tissues. The rumen wall had the appearance of being inelastic and puckered in a manner that might result from scarring. The general appearance of the rumen was that it had suffered from the hemorrhagic condition and the blood had been resorbed prior to the time of the autopsy. The rumen contents were less than normal in amount, compact, dark in color and of a stale odor, indicating the rumen had not functioned for some time. The interpretation we place on these findings is that the fawn suffered the hemorrhagic condition and survived the acute stage only to succumb later from its general debilitation and possibly malnutrition as result of damage to the digestive tract.

INVESTIGATIONS

Toxic substances. In our investigations to determine the cause of the deer mortality consideration was given to two most plausible agents: toxic substances and infectious disease. Commercial toxic agents, such as herbicides and insecticides, and water pollution were ruled out because the deer in many areas had no opportunity for such contact. The sudden and sporadic appearance of the mortality made us suspect that toxic plants might be involved. This theory was given support when our attempts to isolate pathogenic organisms from fresh carcasses by bacteriological culture methods and laboratory animal inoculation proved unsuccessful. Bracken fern, considered to be toxic to livestock when eaten over a period of time, was regarded with some suspicion because it is widespread in distribution and the pathological change produced by it is characterized by a hemorrhagic condition. However, our prior experiments in which captive deer were fed a diet containing bracken indicated deer may eat considerable amounts of the plant over a long period of time without showing any clinical effects.

In early October, Drs. John Cantlon, Quentin Jones and George Parmelee, botanists with Michigan State University, made a poisonous plant survey at seven sites in four counties where deer mortality was observed. They noted the potentially poisonous species present, the extent of deer browsing on these species, and the general browse conditions for deer. It was their conclusion and opinion that, if the deer were dying from eating poisonous plants in the areas where the carcasses were found, the cherry species were the most logical suspects. There was no evidence from the rumen contents of the dead deer that they had been feeding heavily on cherry. Tests for hydrocyanic acid, the toxic agent that evolves from cherry leaves, were made on several rumen samples. One sample was from a deer that had been dead only a few minutes. All the rumen samples were negative for hydrocyanic acid.

Media inoculation. In the bacteriological phase of the investigation repeated attempts were made to isolate from the organs and body fluids of fresh carcasses any bacteria that might be the cause of the deer deaths. The culture media used were brain-heart infusion with agar, tetrathionate broth, thioglycollate fluid medium, and blood agar plates. Inoculations were made on these media from blood, pericardial fluid, urine, kidney, spleen, liver, intestinal contents and rumen contents. The inoculated media were incubated under aerobic and anaerobic conditions. On none of the media did any bacteria grow which could be considered responsible for the deer mortality. Specific tests for leptospirosis, tularemia, brucellosis, and listeriosis were negative.

Laboratory animal inoculation. White mice were given subcutaneous and intraperitoneal injections of thoracic fluid from dead deer. In addition, tissue material consisting of liver, spleen, and kidney from the deer was ground up into a liquid suspension and injected into mice, domestic rabbits, and hamsters by the subcutaneous and intramuscular routes. Later in the course of the investigation two lambs of about 70 pounds in weight were injected intramuscularly with a similar tissue preparation. Cottontail rabbits, snowshoe hares, and a red squirrel were injected with tissue preparations. None of the inoculated animals developed clinical symptoms of infection.

Deer inoculation. In an initial test, four fawns about five months old were inoculated, each by a different route. The source of the inocula was a wild sick deer, No. 55-116. One fawn, No. 55-121, was injected intramuscularly in a rear leg with one and one-half milliliters of tissue material consisting of liver, spleen, and kidney. The inoculum was prepared by grinding the combined tissues with a mortar and pestle using sand to aid in grinding and enough nutrient broth to make a liquid suspension of the material. An attempt was made to follow aseptic technique in all steps in the preparation to avoid introduction of extraneous organisms. A second fawn, No. 55-120, was given by the oral route several milliliters of the same tissue suspension to which was added a small amount of ground intestine. A third fawn, No. 55-125, was injected with one-fourth milliliter of a 24-hour broth culture of blood removed aseptically from the source deer. The fourth fawn, No. 1257, was given orally about one-half pint of liquid extracted from the rumen contents of the source deer. The results are shown in Table 1. The last mentioned fawn survived. The other three died in eight to ten days. Autopsy findings on the dead deer were identical to those observed in the wild sick deer, No. 55-116, which was the source of the inocula. These results gave strong evidence that a transmittable agent was involved in the deer deaths. To verify this conclusion two deer were inoculated with tissue material from fawn No. 55-121. Fawn No. 55-121 died as result of an intramuscular injection of tissue material from the source deer, No. 55-116. One deer, No. 55-127, was injected intramuscularly with one-half milliliter of a tissue suspension of liver and spleen. A second

TABLE 1. RESULTS OF INOCULATION OF CAPTIVE DEER

Deer number	Sex	Age	Date inoculated	Passage number	Method of inoculation	Result
55-116	Male	5 Mos.			Wild sick deer	Died 20 minutes after capture
55-120	Male	5 Mos.	Sept. 16, 1955	1	Orally, suspension of liver, spleen, kidney, intestine from 55-116	Dead in 8 days
55-121	Male	5 Mos.	Sept. 16, 1955	1	Intramuscularly, 0.5 milliliter suspension of liver, spleen, kidney from 55-116	Dead in 9 days
55-125	Male	5 Mos.	Sept. 16, 1955	1	Intravenously, 0.25 milliliter of 24-hour broth culture of blood removed aseptically from 55-116	Dead in 10 days
1257	Male	5 Mos.	Sept. 16, 1955	1	Orally, rumen liquid from 55-116	Survived
55-126	Female	5 Mos.	Sept. 28. 1955	2	Intramuscularly, 1 milliliter filtrate of liver, spleen from 55-121, Seitz filter	Moribund at 7 days; sacrificed
55-127	Male	5 Mos.	Sept. 28. 1955	2	Intramuscularly, 0.5 milliliter suspension of liver, spleen from 55-121	Symptoms at 7 days; recovered
55-131	Male	1½ Yrs.	Oct. 7, 1955	3	Intramuscularly, 1 milliliter blood drawn aseptically from 55-126	Dead in 7 days; autopsy inconclusive
2540	Male	2½ Yrs.	Oct. 26, 1955	3	Orally, approximately 15 grams fresh feces from 55-126	Survived (no symptoms)
55-143	Female	5 Mos.	Oct. 25, 1955	3	Intramuscularly, 1.5 milliliters suspension of liver, spleen from 55-126	Dead in 10 days
55-144	Male	5 Mos.	Oct. 25, 1955	3	Intramuscularly, 1.5 milliliters filtrate of liver, spleen from 55-126, Seitz filter	Dead in 10 days
2540	Male	2½ Yrs.	Oct. 25, 1955	3	Intramuscularly, 1.5 milliliters suspension of liver, spleen from 55-126	Survived (no symptoms at 10 days). Shot Oct. 15, 1955 because ugly.
56-6	Male	7 Mos.	Jan. 9, 1956	3	Intramuscularly, 1.5 milliliters filtrate of liver, spleen, kidney from 55-126, Seitz filter	Survived (no symptoms)
56-7	Male	7 Mos.	Jan. 9, 1956	3	Intramuscularly, 1 milliliter suspension of liver, spleen, kidney from 55-126	Dead in 9 days
56-22	Male	Adult	Jan. 24, 1956	4	Intramuscularly, 2 milliliters filtrate of liver, spleen, kidney from 56-7, Seitz filter	Survived (no symptoms)
56-23	Male	Adult	Jan. 24, 1956	4	Intramuscularly, 2 milliliters filtrate of liver, spleen, kidney from 56-7, Seitz filter	Survived (no symptoms)
56-23	Male	Adult	Feb. 10, 1956	4	Intramuscularly, 2 milliliters suspension of liver, spleen, kidney from 56-7	Survived (no symptoms)
56-28	Male	Adult	Feb. 10, 1956	4	Intramuscularly, 3 milliliters filtrate of liver, spleen, kidney, from 56-7. Millipore filter	Symptoms at 11days; sacrificed at 12 days
56-29	Male	7 Mos.	Feb. 10, 1956	4	Intramuscularly, 3 milliliters filtrate of liver, spleen, kidney, from 56-7. Millipore filter	Survived (no symptoms)
56-32	Female	Adult	Feb. 21, 1956	5	Intramuscularly, 5 milliliters fresh blood from 56-28	Dead in 5 days

deer, No. 55-126, was injected intramuscularly with one milliliter of a filtrate prepared by passing some of the suspension of liver and spleen through a Seitz filter to remove bacteria that might be in the inoculum. We did not have the specifications on the filter pad used. When tested, the pad did not allow the bacteria, *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* in a test broth culture to pass through. The filtrate proved bacteriologically sterile when streaked and incubated on culture plates. Deer No. 55-127, injected with the tissue suspension, showed symptoms of infection at seven days, but eventually recovered. Deer No. 55-126, injected with the filtrate, was moribund at seven days when it was sacrificed for a source of fresh tissues. The results of the second serial passage in deer left little doubt that a transmittable agent was involved. Our repeated failures to recover bacteria from the organs of stricken deer plus the infectivity of a tissue filtrate that passed through a filter pad of sufficient density to hold back small bacteria gave strong evidence that the agent was a virus.

Subsequent experimental inoculations of deer were conducted to verify prior results and try out different routes of exposure that might give some information on the mode or modes of transmission of the disease in the wild. With a few exceptions deer were readily infected by an intramuscular injection of a suspension made of liver and spleen and with or without the addition of kidney obtained from deer sick or dead from the disease. The results were less consistent when the tissue suspensions were filtered through a Seitz filter to remove bacteria inasmuch as only one deer, No. 55-144, died, whereas three, Nos. 56-6, 56-22, 56-23, survived without developing clinical symptoms. These failures may be ascribed to chance encounters with resistant deer and/or technical difficulties connected with the filtration process. Authorities in virology point out that particles as small as many of the viruses may be absorbed onto and thus held back by some types of filters due to physical and chemical phenomena. To circumvent the problem, Dr. Walter Mack of the Department of Microbiology and Public Health at Michigan State University, prepared for us a filtrate from a suspension of liver, spleen and kidney from deer No. 56-7. The tissues were put through a preliminary treatment in which they were liquified in a Waring blender, diluted and mixed with nutrient broth, and centrifuged at a low speed to throw down the coarser tissue debris. The supernatant liquid was turned over to Dr. Mack who centrifuged it in a refrigerated centrifuge to throw down the bacteria and larger particulate matter. He then removed the supernatant liquid and passed it through a Millipore filter, Type HA, of a porosity that removes most bacteria without retaining most of the virus particles. The filtrate obtained through this process was bacteria free when streaked on plate media. Two deer were injected with this filtrate. One deer, No. 56-28, an adult buck, refused food on the 10th day and showed clinical symptoms of sickness on the 11th day following inoculation. The other deer, No. 56-29, a male fawn about seven months old, showed no symptoms at any time. The adult buck, No. 56-28, when sacrificed on the 12th day showed the typical hemorrhagic lesions upon autopsy. No bacterial growth was obtained on culture plates inoculated with organ material from this deer. It became quite evident that the infective agent was filterable.

DISCUSSION

Clinical behavior of artificially infected deer. The deer experimentally infected developed an acute disease that usually resulted in death in eight to ten days following inoculation. Typically, the first clinical sign of infection was observed about a day prior to death when the deer refused to eat. They still retained their wildness when approached by a person but if undisturbed they were inclined to spend much of their time lying down or in retirement in their shelters. Deer No. 55-127, which eventually recovered, refused food beginning the seventh day after injection, developed some swelling in the mandibular region, ''drooled'' saliva from its mouth and spent much of the time lying in its shelter. The conjuctiva was noticeably reddened and somewhat swollen. This deer gradually recovered and resumed eating after several days. There was no evidence of diarrhea in any of the animals. In a few instances the well-formed fecal pellets were streaked with red blood. In the final stages just prior to death the deer were in deep depression and, although able to stand, showed no concern for humans or loud noises. Temperature readings were variable, ranging from 101 degrees and 102 degrees for deer that were approaching a moribund state to 103 degrees and 105 degrees for those that were yet quite active although showing definite symptoms of infection. It is impossible to say if the temperature elevations in the few deer where it occurred was the result of the infection or the excitement of capture and restraint. The most outstanding characteristic of the disease seemed to be the sudden death of the deer. Several of the deer that showed only the slightest indication of infection on an afternoon were found dead the next morning.

Resistant individuals. Of 18 deer inoculated with material and dosage of proven virulence there is evidence that two and possibly three were resistant to infection. Deer 56-23, an adult buck, showed no symptoms following an injection of a tissue suspension of liver, spleen, and kidney from deer No. 56-7 which proved to be infective to another deer. Deer No. 56-29, a male juvenile, showed no symptoms following a dose of tissue filtrate that was fatal to adult buck No. 56-28. A third deer, No. 2540, an adult buck, injected with a tissue suspension of proven virulence showed no symptoms for up to 10 days when he had to be killed for safety reasons. The reasons for the apparent non-infection in the other deer may be attributed to the route of inoculation or to non-infective materials as seemed to be the case with some of the filtrates.

Contact exposure. The results of observations and limited trials with captive deer indicate the disease is not highly contagious, or at least it was not under the conditions of the experiments. Several healthy deer were exposed by placing them in pens recently occupied by sick deer and in which the feed, water, and droppings were let remain. The pen arrangements and available space did not permit complete isolation of experimentally infected deer, consequently, some of the sick deer were confined in pens adjoining pens containing healthy deer and separated only by a wood picket fence. As yet we are not aware of any deer that has become infected through these modes of exposure.

The result obtained with deer No. 55-120 indicates that deer may be infected by ingesting infective material. Our attempts to infect a door, No. 2540, with feces from a sick deer were inconclusive because the deer apparently was resistant to infection as was shown by subsequent tissue injections.

Blood transmission. The results of three trials indicate the blood of a sick deer is highly infective when injected into a healthy deer. Deer No. 55-125 was dead 10 days following an intravenous injection of one-fourth milliliter of a 24-hour broth culture of blood taken from a wild sick deer, No. 55-116. The broth culture was bacteriologically sterile when tested on a bacterial medium. If the infective agent is a virus, as appears to be the case, the broth must have served merely as a diluent since it is not a suitable medium for virus multiplication. Deer No. 55-131 was dead seven days following an intramuscular injection of one milliliter of blood taken from a sick deer. The results of the autopsy were inconclusive at the time because distinct gross lesions were lacking. In view of the results from still another deer, No. 56-32, however, it appears that this was an authentic case. Deer No. 56-32 was dead five days after an intramuscular injection of five milliliters of blood from a sick deer. The apparent infectivity of the blood of sick deer gives support to a hypothesis that the natural mode of spread of the disease among deer may be through an insect vector.

Preservation of infective tissues. No difficulty was encountered in maintaining the virulence of tissues collected for sources of infective material. In warm weather the dead experimental deer were autopsied with little delay or, if that was not possible, the entire carcass was frozen for later autopsy. Liver, spleen, and kidney tissues stored in glass containers or pasteboard containers in a freezer at about —20 degrees C. were still infective three months later. We do not know how much longer infective material may be maintained.

Effect of the disease. It is too early to predict what ultimate effect this highly fatal disease of deer may have on the Michigan herd. However, some encouragement may be gained from the preliminary kill figures on the 1955 deer season. Despite the fact the disease was widespread, occurring in at least 10 counties, the buck take in the Lower Peninsula was up slightly from that in 1954. From this it would appear the reduction in deer population as result of the disease was only local.

The disease may not be new to Michigan inasmuch as a deer die-off on a smaller scale occurred in the fall of 1953 when upward of 50 dead deer were found in the Lower Peninsula. The deer were found principally in three counties. Only one of the counties lies within the current die-off area. The autopsy findings in the deer examined were similar to those in the deer examined this year.

A question often asked by hunters is whether there is danger to persons who come in contact with sick deer. Conservation Department disease workers and other personnel have had frequent exposures through handling and autopsying deer that died from the disease. We have no evidence that the disease can be transmitted to humans.

Other states. It is possible that the same disease exists in other states. An account is given by Shope, *et al.*, (1955) of an epizootic in deer that took place in New Jersey in the summer of 1955. The disease was found to be caused by a virus. The pathological picture described is very similar to that found in the Michigan deer. While no comparative work has been done as yet there is evidence that the two outbreaks are of the same disease.

SUMMARY

1. An epizootic occurred among white-tailed deer in the Lower Peninsula of Michigan in the late summer and fall of 1955.
2. The principal autopsy findings in the dead deer were hemorrhages involving most of the internal organs and the muscles and subcutaneous tissues.
3. No pathogenic agents were isolated by bacterial culture methods or laboratory animal inoculations.
4. Deer were readily infected by injections of tissue material or blood from a sick deer.

5. Bacteria-free filtrates of tissue material from sick deer was infectious to healthy deer.
6. The disease appears to be specific for deer.
7. The disease was not transmitted to susceptible deer by contact exposure under the conditions of the experiments.
8. There is evidence the disease has occurred previously in Michigan.
9. The pathological picture in dead deer closely resembles that in deer in New Jersey which died in the summer of 1955 from an epizootic caused by a virus.

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DISCUSSION

MODERATOR WHITLOCK: Of course, the main question in this case is what you can do about it and there seems to be very little of a practical nature that can be done. However, it is an argument, let's say, for keeping the deer herd within reasonable bounds, although in this case it was indicated that some of the die-offs did occur along fringe areas.

MR. DAVIS [Colorado]: I did not get the incubation period on the experimental animals.

DR. FAY: The incubation period generally ranged from 7 to 10 days. The characteristic of the urine seems to be normal. In no case did we receive evidence of bloody urine. There were one or two deer in which we observed bleeding of the bladder, but it was not a consistent finding. I should say that these pictures were a composite or accumulation of pictures from several deer.

MR. DELLINGER [Arkansas]: We had something similar to that, but we noticed blood in the chest cavity. This was indicated in one deer from an area that was heavily populated and in another deer from an area not quite so heavily populated but adjacent to the heavily populated area.

DR. FAY: Our findings involved mostly the organs. We did find a quantity of fluid in the chest cavity at times.

DR. HERMAN [Maryland]: I would like to present a different philosophy than is being currently considered here concerning the occurrence of disease in deer.

If we look at the history of disease in humans and in livestock of domestic species, we see equally complex problems presented, and yet, through extensive research and study, methods are being found to control those diseases. I am quite optimistic with regard to this in spite of the limitations of our field of study of wildlife species and I feel that it is a case that, if and when we get enough information, we will ultimately be able to control disease in wildlife just as we are attempting to control other factors in producing a harvestable crop. I think that the day is coming when we are going to be able to present some solutions for management procedures.

CHANGING TRENDS IN PREDATOR MANAGEMENT

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The past decade has seen pronounced changes in predator control practices throughout the United States due to the cumulative effect of a gradual transition away from pioneer conditions in previous decades, and an acceleration of economic and sociological trends since the last war. A survey of these factors was made during the fall of 1955, and in December and January state game commissions and other agencies cooperated in a survey of predator management methods now being used throughout the United States. These surveys reveal some interesting facts which may be useful to game officials in adapting predator management to changing conditions.

The transition away from pioneer conditions is not as complete, with regard to predator management, as might be expected in this new age of automation and atomic energy. Retention of the old idea of indiscriminately subjugating the wilderness is a factor in the public support of bounties on predators, which still persists in many places. Out of 46 states which replied to recent questionnaires on predator management, 33 have bounty programs at state, county, or local level. In seven of those, bounty is the only method of managing predator populations. Progressive opinion is favorable to removal of bounty in 15 of the 33, and in three others there is sentiment for a bounty reduction by limiting it to certain areas or species. These progressive ideas, however, represent a minority of public opinion in most cases. The general public has not yet been fully educated to the wasteful and indiscriminate nature of bounty systems, and only three states reported bounty eliminations or reductions as a major aspect of changing predator management in the past decade. Hence we have the anomalous situation of an archaic attitude on predators persisting in a society of television viewers.

The effects of changing economic conditions on the utilization and management of wildlife are so well recognized as to require little comment here. Nearly all of the answers received in this survey reflected changes in predator management due to inflation. An indirect economic factor, widely known but mentioned in only six replies, is the unfavorable market for long-haired furs which has characterized the past 25 years. This has discouraged private trapping, thus contributing to increases in long-haired fur animals, several of which are classed as predators in many states. In the absence of incentive for predator control by private trappers, an increasing burden of alleviating predator damage has fallen on governmental agencies.

In a few cases the public demand for government aid has turned toward state bounty payments to subsidize private trappers.

Changes in land use are less apparent than purely economic factors, but they exert on predator management a decided influence which is likely to increase as competition for land becomes more intensified. In the complexities of local land use practices our survey revealed four sectional trends which are affecting or must soon influence predator management: (1) The expansion of southeastern grassland agriculture; (2) an increase in forested lands, particularly in the Southeast and West; (3) accelerated fencing of the open ranges; and (4) extension of urban and suburban influences, most noticeable in the Northeast.

Southeastern grassland agriculture is apparently influencing predators more than would be indicated by acreages involved. Replies to questionnaires sent to agricultural agencies in six southeastern states showed that actual acreage of pasture land has increased only nine per cent in those states during the past 10 years. Accompanying this, however, has been a 60 per cent increase in beef cattle, largely made possible by improvement of existing pastures and consolidation of small farms into the larger holdings necessary for efficient beef production. It is the latter trend which appears to be influencing predator populations. The old pattern of small fields and frequent fence rows is giving way to large blocks of woods or pasture. The consequent decrease of ''edge'' environment may result in smaller populations of foxes and other wildlife. Such trends in wooded areas in this direction are indicated in unpublished information on current studies of fox populations in Georgia by John E. Wood, under the direction of Dr. David E. Davis. In pastures a trend is not yet apparent and foxes are an increasingly important factor in the grassland economy, as will be shown in later discussions on rabies.

Although the effect of increased forest areas upon predator populations is somewhat obscure, it is clear that lands converted to forestry become less useable by livestock, and stockraiser's demands for predator control on such lands are correspondingly reduced. Trends in forested lands are summarized in the following quotation from the review draft of the *Timber Resource Review:*

> ''Until the opening of the 20th century, clearing for farm use resulted in a steady decline in forest area, . . . but for the last several decades the area returned to forest has exceeded the area cleared. . . . This great readjustment has about run its course in the North. It has probably passed its peak in the South. And in the West it has never been more than of local importance.''

The third land use factor, fencing of the open range, has increased rapidly in the past decade. This is due to the scarcity and high cost of competent sheep herders, the increasing valuation of grazing land, and the improvements in predator control which make it practicable to turn sheep loose in pastures without constant guard against coyotes. Fencing, in turn, has partially limited the movement of predators and in some instances has aided the task of maintaining them at a low population level.

It seems likely that the fourth item, increasing of suburban areas, may eventually become an important land use factor influencing the management of predators and many other kinds of wildlife, but at present it is little more than a local nuisance factor except in the northeastern states. Prohibitions against hunting, which are customarily considered necessary to public safety in suburban areas, result in increased numbers of certain wildlife, including some predators. The resultant small amount of damage to poultry around widely spaced metropolitan areas is of slight consequence, but in thickly settled portions of New England and nearby states it is becoming a problem which sometimes affects entire counties.

All of the factors previously discussed are direct or indirect manifestations of the basic factor of human population pressure, which is increasingly affecting all phases of wildlife and wild land management. A human population factor not previously mentioned is that of transmission of disease from wild animals to man. Statistically, this is a very small problem even in outdoor recreational areas where many people have close contact with animals. Fortunately, too, modern medicine has found effective answers to some of the most deadly of animal-borne diseases, such as typhus and plague. But the problem of controlling rabies, the disease most dreaded in contacts with predators, is not yet solved in the United States. The problem of its transmission to domestic stock is also of great economic significance. It is a factor which requires attention in the predator management programs of practically all states east of the Mississippi, aside from New England, and it was listed by 12 states as either the primary or secondary objective of predator control. Its increasing importance is shown by the fact that in our survey it was the most frequently named cause of changing trends in predator management during the past 10 years. West of the area of fox abundance, where coyotes and wolves were once the chief wildlife carriers of rabies, there have been no serious widespread rabies outbreaks since the Biological Survey, a predecessor agency of the Fish and Wildlife Service, was requested to join with the western states in suppressing the destructive out-break of 1915-1918. Skunks are the wildlife species most frequently involved in the few trouble spots that have developed since then.

To complete this discussion of factors and trends in predator management it may prove helpful to summarize the results of the survey made at the close of 1955 through the cooperation of state game officials and others. Repetition of information already stated will be avoided so far as possible.

Replies were received from all but two states. The questionnaires to these apparently were lost or delayed in the rush of holiday mail. Among the 46 states replying, three had (in 1955) no program of predator management, five had programs conducted by state agencies other than the game department, and in 38 the game department was engaged in such work directly or indirectly. Out of the 43 states having predator programs, 16 which are in the ranges of the larger predators conduct the work in cooperation with the Fish and Wildlife Service. This way of doing the work has general public support in the Western states. In the central and eastern states, where predator damage to livestock and poultry is smaller and more localized, there is a trend toward an extension service type of predator management. Two states rely chiefly on this method, and six others use it to a certain extent. Four of these do so in cooperation with the Fish and Wildlife Service, making a total of 20 which maintain such cooperation.

Continuation of predator management was desired by the operating agencies in 42 of the 43 states now so engaged. Nine desired continuation and expansion of the existing program; five desired continuation but without bounty; two, continuation and modification of the program, which did not include bounties in 1955; three, continuation with complete reorganization to eliminate the dominating bounty system; one, reorganization to place predator control under some agency other than the game department; and one, complete abandonment of predator management, which consisted solely of bounties. The primary reason for recommendations by the last two was the feeling that predator management was not necessary to successful management of game.

In only nine states was "aid to the increase of game populations" given as the primary objective of their predator management work, and seven others listed it as the secondary objective. The most common objective was "to aid in increasing livestock and poultry production," a primary objective in 19 states and secondary in three others. A total of 20 states were pointing their programs toward "integration of predator management with game management for the benefit of all wildlife,'' four states giving it first priority, and 16 second. Suppression of animal-borne diseases was the fourth most frequent objective, eight primary and four secondary. Six states listed reduction of damage claims and complaints as an objective, and only one named ''to encourage activities of private trappers'' as an objective.

A surprising variety of creatures are classed and managed as predators in several states. Those listed in the survey are here preceded by numbers denoting the number of states in which each was in 1955 classed as a predator: 31, bobcat; 29, fox; 23, coyote; 13, wolf; 12, puma; 11, skunk; 10, bear and raccoon; 9, weasel; 8, badger; 3, opossum and crow; 2, lynx, groundhog, and ''owls''; 1 gopher, starling, magpie, ''hawks,'' feral dog, feral cat, and rattlesnakes. There may have been more, as several replies did not specify kinds when checking ''other.''

An attempt was made, in the survey, to learn the total expenditure for predator management in the United States. Nearly half of the replies, however, indicated that complete data was not readily available, especially with regard to county and local bounty payments. On the basis of incomplete returns, it appears that bounty payments in relation to all other costs of predator management had a ratio of about one to two.

The surveys conducted in late 1955 and early 1956 show that predator management in the United States is being administered and conducted by men who are aware of current changes in conditions affecting the work, and who are prepared to adapt their programs to keep pace with these trends. Progressive actions have already been taken and are being continued to meet the increasing threat of rabies transmission by wildlife. Similarly, administrators are keeping pace with rapidly changing economic conditions. Generally speaking, less attention is being given to the effects of regional trends in land use, probably because these are less apparent. These trends include expansion of cattle raising in the Southeast, reduction of wildlife habitat by increases there of large blocks of grassland and forest, and of forested acreage in other sections; fencing of the open range; and booming ''suburbia'' in the Northeast and around metropolitan centers elsewhere. One of the most noticeable trends in predator management is the increasing desire on the part of administrators and technicians to discard bounties. Equally noticeable is the reluctance of the general public to support such a change. It is apparent that in this atomic age, in which most people place reliance upon the specialized knowledge of physicists and chemists, they have not been as thoroughly educated to rely upon wildlife specialists. Too many cinemascope viewers of today are still in the silent movie era so far as predator management is concerned.

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DISCUSSION

MODERATOR WHITLOCK: Are there any questions? I know that in my part of the country the predator situation, as far as bounties are concerned, is with us yet, despite all of the efforts of our research people to show that predators have little or nothing to do with game abundance. We do believe that a certain amount of control is necessary. We cannot ignore damage to agricultural interests for they have to be considered. What the situation may be in other parts of the country I do not know. I suspect that predators are given more credit for doing damage than they actually deserve but that may not be the case in some selected areas.

Has anyone any comments to make on the paper just given?

MR. SELKE [Minnesota]: I wonder if the speaker would comment on whether there are changing trends in public attitude toward the predatory animals and particularly with regard to them as part of the animal life of parks and wilderness areas.

MR. PRESNALL: We received no comment on that in the questionnaires. We did from one state receive a comment that the changing viewpoint of the livestock people, the affected groups, was a major factor. We are conscious of the fact that there is a considerable legitimate interest in predators as a part of the animal community and we are taking steps, in the wilderness areas, to see that those values are protected.

HOW LONG DO DUCK FOODS LAST UNDERWATER?

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As a part of the assistance given to cooperators of local soil conservation districts, Soil Conservation Service technicians plan the use of wet-lands for waterfowl when this is the desired land use. The planting of duck food plants and the manipulation of water levels are among the practices recommended. There are a hundred or more duck food plants but the farm planner needs to know which of these will assure the landowner of successful duck field management.

During the past five years, biologists and plant materials specialists of the Soil Conservation Service, by means of field trials and observations, have attempted to select a half-dozen manageable and useful species of duck food plants. This paper presents only one phase in this selection, namely, that of determining keeping qualities.

In recent years, much of the emphasis in food plants which could be grown for ducks has been placed upon acceptability by ducks and upon high yield. Little consideration has been given to the keeping qualities of the foods. Once considered, it is easy to realize that there is little management value in growing a species of duck food which might produce an extremely high yield but which will rot away within a few weeks. Practical management of duck fields requires a high yield of acceptable food—but equally important—a food which will last with little deterioration through the months when waterfowl are dependent upon it.

Field trials were started in 1953 to measure the comparative rate of deterioration of some selected duck foods when flooded. Although it was realized that the *exact* conditions of a seed lying on the bottom of a duck pond could not be duplicated, two test methods were designed to approximate natural conditions as closely as possible.

One principal location in Colleton County, South Carolina was used for the tests. Another location, about 20 miles distance from the first, was used for tests with duplicate samples of selected species. There was less than five per cent variation in the results at the two locations.

The first requirement to be met was a sample which could be measured before and after a given period of exposure. It was supposed—and experience during the tests proved it true—that volumetric measurement was unreliable. Many kinds of seeds with hard seed coats could have the entire inside meat gone and still occupy about the same volume. Determination of before and after weights of the sample was accepted as the practical approach. However, volumetric measurement was used as a convenient way to portion out the samples before they were weighed so that approximately equal volume quantities of each species of seed were used for the samples.

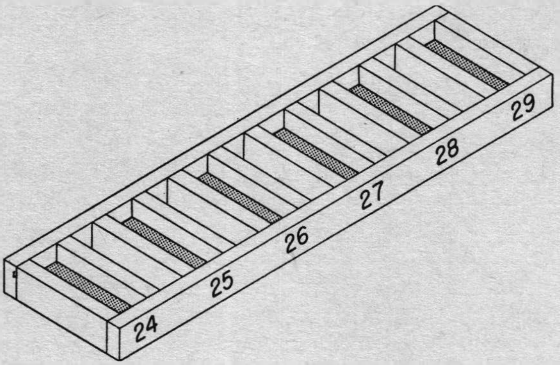
It was also decided that an important part of comparative deterioration measurement was to have every seed sound in the samples to be tested. This was solved by running the seed through a small "Clipper" seed cleaner. When operated with the blower rotated for a strong air current, immature and light seed were easily and quickly separated from the sound seed. The stock supply of all species of seed to be tested were triple-cleaned by this means before the individual samples were drawn from the stock. *Only hand harvested seed was used to avoid scarification which might result from mechanical harvest.*

Approximately 25 cubic centimeters of seed were drawn from the stock and weighed in grams for each sample. With larger seeded species such as corn and soybeans, 100 seed were used although this amount exceeded 25 cubic centimeters. The samples were held in small paper envelopes with the weight recorded on the face until they were ready to be emptied into trays for underwater exposure. After the period of exposure, and as the trays were opened, the samples were returned to their original envelopes. This procedure removed any chance of getting samples confused and also simplified record keeping.

Any attempt to have the one-half dozen or more samples of each species of seed of identical weight was considered useless and time consuming. The exact weight of each sample at the beginning and its weight after exposure are all that need be known to compute the percentage of deterioration. Weighing of samples to the nearest one-tenth gram was found to be accurate enough for the test purposes.

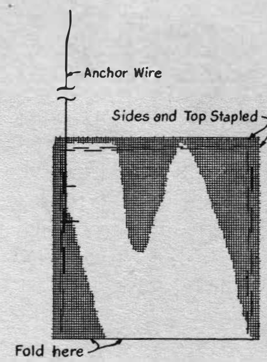
One method of exposing the seed samples was by small trays constructed of seasoned redwood and with the top covered with either metallic or plastic screen material. The bottoms were of the same wood as the sides. Inside dimensions were 6 inches long by 2 inches wide by 1 inch in depth. This size held 25 cubic centimeters of seed spread thinly across the bottom. The trays were substantially constructed of one-inch by two-inch stock so they could be re-used for several years. To facilitate handling, they were assembled in groups of six, spaced two inches apart along wooden stringers or side pieces. (See *Figure 1-A.*) The trays were individually marked by painting numerals on the side pieces.

Each six-tray unit contained six different kinds of seed. This was necessary so that complete sets of samples could be conveniently picked up at the proper time. The number of trays required was based upon the number of different kinds of food being tested and the number of periods for which deterioration was to be measured. For



A

Assembly of a six-tray unit for exposing samples to deterioration underwater. The top is covered with plastic or metallic mesh screen material after the samples are in place. The unit is weighted to keep it submerged (See text).



B

Envelope made of 32 x 32 mesh plastic screen for exposing samples to deterioration under water.

Figure 1.

samples of each of 12 different foods to be removed for analysis every 15 days for 90 days, a total of 72 trays (12 units) was required. Therefore, unless considerable time can be devoted to this type of measurement, the number of different foods which can be studied each season is limited.

To hold the trays at the bottom of the flooded duck pond area, one common brick was wired to each end and one at the center of each series of six trays. The trays were ''set'' in the depth of water normally used in duck fields—10 to 15 inches.

Another method of exposing the samples was by the use of small envelopes constructed of screening material. These were made of 32-by-32-mesh monofilament plastic screen and were four and one-half inches square. They were made by folding a piece of plastic screen four and one-half inches wide by nine inches long and stitching the sides and top with an office stapler. A piece of Number 26 gauge wire four feet long was stitched to one side of the envelope and used to anchor it in position when placed in the water. This also provided a convenient manner of locating the sample after exposure and retrieving it. (See *Figure 1-B.*) The envelopes containing the samples were placed on the bottom of a flooded area at a similar depth as the trays. To avoid crowding of the seeds in the envelopes, approximately 10 cubic centimeter samples were used for the trays. The weight of each sample to the nearest one-tenth of a gram was recorded. Small aluminum tags were numbered and inserted with the seed in the plastic envelopes to serve as identification.

Measurements of the same species of seed by the tray method and by the plastic screen method indicated no more variation than normal between duplicate samples (less than five per cent). Field experience has shown either method to have both advantages and disadvantages over the other in regard to the different phases of the job of loading, setting and handling of the samples.

In an attempt to more nearly duplicate conditions of the pond bottom, an equal amount of marshland soil was mixed with each sample in the first year's tests. The separation of this soil from the seed sample after exposure proved to be difficult and tedious. This procedure was not used the following years. Results with or without soil mixed with samples were within the normal range of variation.

When either the trays or the plastic envelopes were removed from the water after the allowed period of exposure, the contents were washed with a fine spray from a garden hose before the tray or envelope was opened. This effectively and easily removed the accumulation of sediment deposited from the water. Care was taken not to use a spray with enough force to tear apart the softened seeds. The samples were then air-dried. It was found that they usually reached constant weight after one to two weeks.

Water temperatures were recorded at random intervals during the time of exposure. Temperatures varied so much from week to week, or even from early morning to afternoon of the same day, in these shallow waters that any attempt at correlation was considered futile. Recorded temperatures at the depth of the samples ranged from 37 degrees F. (with ice over the water surface at the time) to 67 degrees F. during a period of warm weather. The average of all the temperature measurements during 1953 tests was 50 degrees F.; in 1954, 52 degrees F.; and in 1955, 48 degrees F. Although it is reasonable to assume that water temperature has an effect on the deterioration of seeds, it is of little consequence in the determination of *comparative* rates of deterioration since all of the samples of a series are exposed to identical condition.

The pH of the water was also considered. It ranged from 5.5 to 7.0 in the two locations used for the tests. Although extremes of pH may influence deterioration, it does not affect the *comparative* ratings of foods exposed to the same conditions.

The management practices employed for duck fields prescribed the practical duration to conduct deterioration studies. In the southeastern states, duck fields are usually flooded beginning about October 15 to November 1 and drained the latter part of the following March.

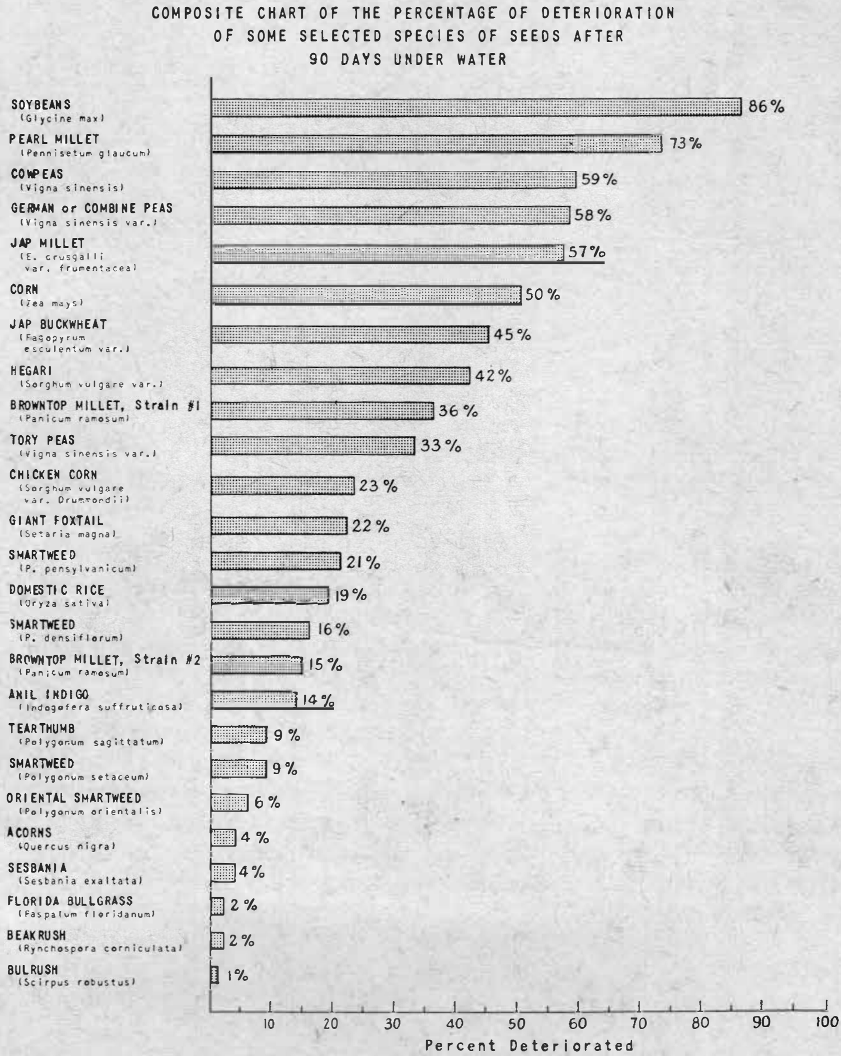

COMPOSITE CHART OF THE PERCENTAGE OF DETERIORATION OF SOME SELECTED SPECIES OF SEEDS AFTER 90 DAYS UNDER WATER
SOYBEANS (Glycine max) 86%
PEARL MILLET (Pennisetum glaucum) 73%
COWPEAS (Vigna sinensis) 59%
GERMAN or COMBINE PEAS (Vigna sinensis var.) 58%
JAP MILLET (E. crusgalli var. frumentacea) 57%
CORN (Zea mays) 50%
JAP BUCKWHEAT (Fagopyrum esculentum var.) 45%
HEGARI (Sorghum vulgare var.) 42%
BROWNTOP MILLET, Strain #1 (Panicum ramosum) 36%
TORY PEAS (Vigna sinensis var.) 33%
CHICKEN CORN (Sorghum vulgare var. Drummondii) 23%
GIANT FOXTAIL (Setaria magna) 22%
SMARTWEED (P. pensylvanicum) 21%
DOMESTIC RICE (Oryza sativa) 19%
SMARTWEED (P. densiflorum) 16%
BROWNTOP MILLET, Strain #2 (Panicum ramosum) 15%
ANIL INDIGO (Indogofera suffruticosa) 14%
TEARTHUMB (Polygonum sagittatum) 9%
SMARTWEED (Polygonum setaceum) 9%
ORIENTAL SMARTWEED (Polygonum orientalis) 6%
ACORNS (Quercus nigra) 4%
SESBANIA (Sesbania exaltata) 4%
FLORIDA BULLGRASS (Faspalum floridanum) 2%
BEAKRUSH (Rynchospora corniculata) 2%
BULRUSH (Scirpus robustus) 1%
10 20 30 40 50 60 70 80 90 100
Percent Deteriorated

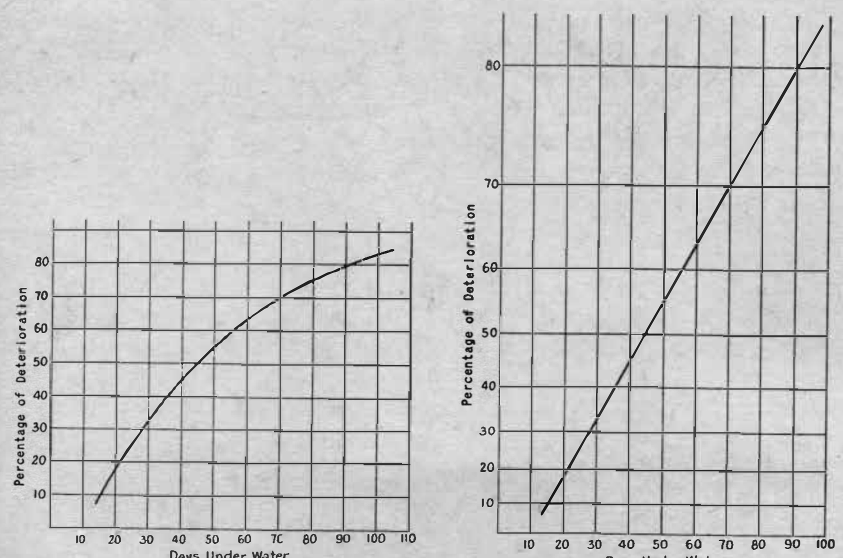
Figure 2.

There appears to be no need to measure deterioration of foods for any longer period. Observation has shown that there is a rapid germination of seeds which are left undeteriorated at the time of the spring draw-down. For this reason, measurement of the seed which might last over from one season to the next is best done by ground sampling during the summer months by the method described by Davison *et al.* (1955) and Haugen (1955).

The percentages of deterioration of 25 species of seeds at the end of 90 days underwater is illustrated graphically in *Figure 2.* Sesbania was included in the tests to determine if rapid deterioration underwater might be the reason this prevalent wetlands species is not utilized by ducks. As *Figure 2* illustrates, quite the opposite was found true, the seeds were extremely resistant to deterioration.

The processes of deterioration may reduce the palatability or acceptability to ducks of some of the seeds tested, such as cowpeas, even though a considerable percentage of the seed are left. The foul odor which some of the seed had after a few weeks of immersion aroused doubt that they would be eaten. However, this type of study was outside the scope of the present investigation.

Figure 3-A illustrates a typical curve of percentage of deterioration



A
Rate Of Deterioration Plotted On Conventional Cross-Section Graph Paper Results In An Exponential-Type Curve.

B
Rate Of Deterioration Plotted On Semi-Logarithmic Graph Paper Results In A Straight Line.

Figure 3.

versus time underwater. All species were found to follow the same exponential pattern but the curve was steeper or more flattened to correspond to the deterioration rate of the species.

When the same values are plotted on semi-logarithmic paper rather than cross-section paper, a straight line results. (*See Figure 3-B.*) To the mathematically inclined this will suggest the formulation of an equation to express deterioration. However, for practical application, a straight line graph is useful to interpolate percentages between measured percentages of deterioration and also to cautiously project values beyond the time interval actually used for a test.

Where only a comparison of the relative keeping qualities of duck foods is desired, the methods described above can be simplified to use only one tray or plastic screen envelope for each species. The samples are removed and analyzed after a single period of exposure, for example, 100 days. This short-cut system has application for the rough classification of species into those with rapid and those with slow rates of deterioration. However, because of the exponential nature of deterioration, with the one-sample method no inference can be drawn as to the amount of food which would be undeteriorated at any time before or after the exposure period of the sample.

A sidelight of the deterioration study may be of interest to plant materials technicians as a lead towards the development of strains of food plants which produce seeds with better keeping qualities. For example, with some of the more rapidly deteriorating seeds, such as soybeans, it was found that practically the entire sample may have rotted and disappeared and yet there might be a single seed left which exhibited no effects of deterioration. This suggests that a selection of plants might be grown from this resistant seed and developed into pure strains to produce duck foods with several times the normal resistance.

Another similar instance may be noted in *Figure 2* in the case of browntop millet. The samples of seed gathered from one particular stand (designated as Strain No. 2) proved to be much more resistant to deterioration than those tested from all other sources used (designated Strain No. 1). This appears to offer definite encouragement for better selections of this useful species for duck food plantings.

SUMMARY

The rate of deterioration when underwater is an important consideration in the selection of duck foods to be grown in practical management. There is little point in having a high yielding food which rots away within a few weeks.

Field measurements of comparative rates of deterioration were

made by exposing samples of seeds underwater in trays or plastic screen envelopes. Percentage of deterioration was computed by weighing the samples before and after exposure.

Only hand-harvested seed was used for the samples to avoid scarification which might result from mechanical harvest. Unsound seed were separated by the air current of a "Clipper" seed cleaner.

The species of seeds tested were found to vary greatly in keeping qualities. The percentage of deterioration of 25 species after 90 days underwater is presented graphically in *Figure 2.*

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DISCUSSION

MODERATOR WHITLOCK: Are there any comments? I must confess that when I looked at the title of this paper that it did not look very meaty to me but that after I had gone through the abstract it seemed to make a lot more sense.

DR. WARD SHARP [Pennsylvania]: Over the past several years we have been doing quite a bit of work on cornweed. I would like to ask the speaker one question—did you find any infection here from bacterial rotting or the type of stratification?

MR. NEELEY: As far as we are concerned, we found no infection.

ENVIRONMENTAL CONTROL IN WATERFOWL

CLINTON H. LOSTETTER
U. S. Fish and Wildlife Service, Sacramento, California

The continued draining of lands by reclamation projects in the West has expanded our agricultural industry. These projects have markedly reduced or eliminated much of the once abundant and satisfactory natural waterfowl habitat.

In an effort to restore, in some degree, these lost natural areas, an environment has had to be created. Such a developmental process on federal and state wildlife areas has been under way for several years on the Pacific Flyway, particularly in California. This process of waterfowl management has greatly assisted in maintaining the Flyway and Continental resource.

The cost of operating these governmental management areas has risen during the past several years, and yet their developments cannot fully meet the birds' habitat demands. In this habitat control phase of waterfowl management program assistance can be attained by the development and improvement of privately owned lands. In California, a vast, relatively untouched reservoir of private lands needs only technical assistance to bring about more suitable living space for fall and wintering migratory waterfowl.

AGRICULTURAL EXPANSION AND HABITAT LOSS

The migratory waterfowl of our international and continental resource are, for the most part, linked to agriculture, whether it be on the nesting grounds of some Canadian prairie province or on the fall and wintering areas of the Central Valley of California. Agriculture in one way or another plays a part in the bird's ecology. Hence, it is only proper to consider the results of the impact of our expanded agricultural industry in relation to our waterfowls' management.

During the last half century, our food and fibre production have expanded more rapidly than food consumption expanded, with corresponding increases in population, wealth and income. Several developments combined to make possible this expansion in farm output. Among these developments, the increased use of mechanical power, improved crop production, and better management practices—all have played an important role (Johnson, 1955).

Greatly assisting the above agricultural developments, during the past two decades in particular, has been the accelerated reclamation of wetlands. Many of these reclamation projects have hastened the decrease of once favorable waterfowl areas, and turned them into highly productive croplands. Thus, in the process of economic agricultural evolution, suitable habitat has been reduced at an alarming rate. The expansion of crop producing areas has been necessary in order to meet our domestic consumption demands for farm products, as well as to satisfy certain export trade demands. Our waterfowl have been forced for survival to go elsewhere onto the markedly reduced natural habitat, or onto newly developed croplands (Lostetter, 1954). Many times, agriculture and waterfowl demand the same lands and water, and in reality are in competition. We have this competition today in some parts of the West. It has been inevitable that this situation should be so pronounced before us. And this conflict, no doubt, will continue or increase as natural waterfowl areas shrink (Lostetter, 1955).

According to the Inventory for the Wetlands of California (U. S. Fish and Wildlife Service, 1954a), agricultural drainage projects are rapidly depleting a great deal of the state's original waterfowl habitat. This survey covered those areas which support about 90 per cent of the state's waterfowl use. This work showed that California has about 559,302 acres of wetlands of all categories, exclusive of agricultural lands. Some 445,000 additional acres are seasonally flooded commercial rice lands, which are of considerable importance to waterfowl. These rice fields in the Central Valley were once largely in native marsh. The replacement of these native marshes with rice has created a suitable habitat attractive to ducks. These fields of shallow water contain, in addition to rice, such aquatic waterfowl foods such as millet, sedges, bulrush, duck potato and others. Wetlands produce both food and cover and are available for utilization by waterfowl during the fall and winter migration. At times during the fall, prior to the rice harvest, ducks are herded away as they can do considerable damage if allowed to remain.

In general, the future of wetland habitat and waterfowl hunting in California is becoming more dependent on federal and state waterfowl management areas. Such agency developments in conjunction with the preservation of existing wetlands are essential for the waterfowl resources of the Pacific Flyway since California is the major wintering area.

ENVIRONMENT CREATION TO SUPPLEMENT LOST HABITAT

In order to meet the problem of a rapidly decreasing natural waterfowl habitat created by an expanding agriculture, corrective steps were taken. A change in our refuge and sanctuary concept of management was made which included the planting of cereal and aquatic crops. In California this change was brought about by the increased rice, barley and clover acreages which suffered depredations. In brief, the loss of natural habitat had caught up with the lack of management and precipitated the establishment of planned waterfowl feeding and resting areas.

In 1943 the Fish and Wildlife Service undertook a program to establish management or feeding areas at strategic points in the rice sections of California. Plantings on these areas were made in rice, barley, millet and other crops, leaving them to mature and flooding them for the birds (Horn, 1949). This habitat creation program was an experiment and today, twelve years later, it has proved to be successful. This type of development has set a pattern for waterfowl management by controlling environmental factors of food and water. A duck has to eat somewhere, and studies on designated feeding areas have shown that duck damage to commercial crops can be minimized.

Federal and state management areas, since the inception of this program in California, have made a great contribution to waterfowl management by rehabilitating areas into a suitable habitat. It has been done, for the most part, by controlling the environment through the use of the tools of common sense, research, and proper farming practices. It was reasoned at the outset of this program, and time has shown it to be correct, that it is desirable to manage waterfowl areas by controlling the habitat and by using natural foods and agricultural crops planted on these areas (U. S. Fish and Wildlife Service, 1954b). The basic reasons for management areas have been to provide food, water, and cover, and to hold birds from crops during the early fall period. Plantings of certain cereal crops such as rice, barley and millet have shown remarkable results in reducing threatened and actual crop damages, and likewise have assisted in maintaining migratory waterfowl. On some management areas containing rice or barley crops, waterfowl have shown a preference for these crops over natural aquatic waterfowl foods.

In California it has become necessary to improve the habitat on wild life areas, both governmental and private in order to help main-
wildlife areas, both governmental and private in order to help main-
January winter inventory for 1955 showed that California had over five million waterfowl, or 58.3 per cent of the wintering population of the Pacific Flyway (U. S. Fish and Wildlife Service, 1955a).

In a report to the Wildlife Conservation Board (Gordon, 1950), it was pointed out that existing and newly acquired waterfowl management areas should be developed to produce the most nearly ideal waterfowl habitat. The timing of the crops' availability for the birds is most important in this environmental control program. For example, the planting of millet crops, which mature early in the fall, aids in feeding the early duck migrants, while rice crops that mature during September and October help to fill the need at that period. Consideration of planting dates, growing periods and water controls are all important to bring the crops to maturity for maximum use (Davis, 1950).

Food habit studies by the California Fish and Game Department (Miller, 1955) show that waterfowl food use preference is related to the abundance of the matured crops. During the months of August and early September in the Sacramento Valley, before commercial or management area rice crops are ripe, pintail and mallard diets consist mainly of millet, supplemented by aquatics. Heavier rice usage follows during late September and October, as this crop matures. Barley also was important in this food analysis during August and September when this crop was available on wildlife areas. Commercial barley is harvested by early July and only waste grain is available.

In Figure 1 below is shown a stand of mature rice (*Oryza sativa*) produced on the Sacramento National Wildlife Refuge near Willows, California. This crop produced about 3,300 pounds of seed per acre. In addition to the rice itself, there were other waterfowl foods available, such as millet (*Echinochloa crusgalli*), spikerush (*Eleocharis palustris*), sprangletop (*Leptochloa fasicularis*), arrowhead (*Sagi-*

Figure 1. Mature rice field on Sacramento National Wildlife Refuge, Willows, California, ready for waterfowl utilization, September 1954. Photo by U. S. Fish and Wildlife Service.

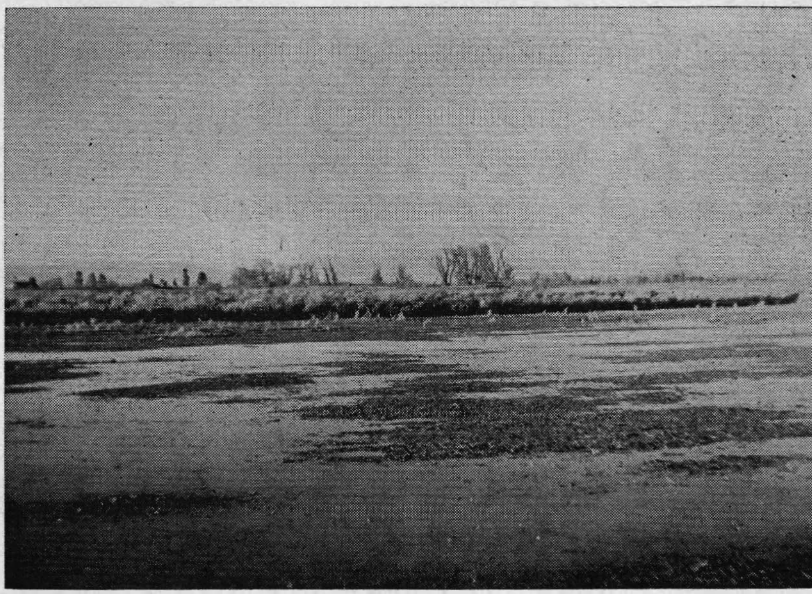

Figure 2. Same rice field as in Figure 1, showing almost complete waterfowl utilization by mid-February 1955. Photo by U. S. Fish and Wildlife Service.

taria sp.), bulrush (*Scirpus fluviatilis*), and rough seed bulrush (*Scirpus mucronatus*).

Figure 2 shows the same rice field as in Figure 1 during mid-February 1955 after almost complete utilization by both ducks and geese. The mature rice seed, for the most part, was consumed by ducks while the straw was taken by geese. In a Service refuge report a food analysis showed that 41 whitefronted goose gizzards contained 38 per cent rice straw, and 33 snow goose gizzards contained 57.6 per cent of rice straw and leaves.[1] It is not clearly understood if rice straw is taken because it is a favored or because it is a plentiful food. It is hardly a quality food as we think of it. Millet straw, as observations show, is refused in favor of rice straw. In this instance, we have seen the complete utilization of this rice crop from seed to straw over a period of almost five months.

Millet is planted on management areas because of its earlier maturity. It fills a need for bird utilization in the period before the rice crop ripens. In years when commercial rice is late in maturing, it is highly important in holding ducks off these rice fields. The crop fills in about 90 days from planting. Field tests by the California Fish

[1]Information from Sacramento Refuge narrative report by Manager V. Ekedahl.

and Game Department in 1954 indicated that some 2,600 pounds of millet seed per acre were produced. On some newly planted areas on good soil, yields of up to 3,000 pounds per acre have been reported. This plant is favored because of its tolerance to certain alkaline soil conditions.

Barley crops planted on waterfowl areas are consumed in the early fall and increase the food availability at that time of year. Green, fall-sown barley affords goose food during the winter period. Standing and mature barley is readily taken by waterfowl, mainly ducks, in a dry or flooded condition.

Also of importance as a food on certain management areas are cattail rootstocks. On the Salton Sea National Wildlife Refuge in the Imperial Valley, California, it has been estimated that over 100 tons of rootstocks are produced per acre. Wintering snow geese, in particular, utilize this food and their feeding makes it available to ducks and coots—sort of a symbiotic food relationship.

In the fall of 1955, some 14,000 planted acres of waterfowl foods were made available on federal and state areas in the Central Valley of California. In the Tule Lake Basin of Northern California, some 6,000 acres of mature grain crops were left standing to be eaten by the birds. These crops, in addition to the natural aquatics on the areas, served well to furnish foods during the fall and winter utilization periods.

It has been demonstrated that most of the cultivated crops on waterfowl management areas produce more pounds of feed per acre unit than a corresponding natural food, with one exception—the cattail rootstock. Nevertheless, it is important to have, if possible, both natural and cultivated crops available during the period that the birds are present. A coordination between the time of planting crops and flooding them on these areas is important in order to receive the most benefit from good crop production of waterfowl foods. This coordinated effort as used in manipulating the habitat has set a pattern for large-scale production of federal and state areas. Such developments have shown positive results in maintaining our migratory waterfowl resource.

Waterfowl habitat development programs have been underway in other states of the Pacific Flyway. Some of the areas are federal, while others are state operated, but all serve a useful part of the overall management scheme. These areas, while less dependent on water than California, for example, do grow crops, both cultivated and natural, as soil, climatic and plant tolerance conditions permit Their programs are important to waterfowl management in their community, their state and the Flyway

HABITAT DEVELOPMENT COSTLY

The purchase and development of waterfowl management areas is an expensive undertaking. Those high operating costs similar to regular farming activities are not cheap in any locality. The millions of dollars that these habitat developments cost is the price we must pay for agricultural expansion and apparent lack of foresight.

According to a recent "Summary of Approved Projects" under California's Wildlife Conservation Board (Calif., 1955), some $4,860,000.00 has been spent on capital outlay projects for waterfowl areas since 1949 for land purchases and habitat development. Four areas alone cost over a million dollars each.

The Fish and Wildlife Service has spent $1,250,000 under the Lea Act for land purchases and development in California since 1949. Some lands that were purchased under this act cost over $200.00 per acre. The Service and the State of California are each annually spending about a half a million dollars in operating the several waterfowl areas within the state.

The pyramiding operating costs of public agency wildlife lands limit their contribution in habitat development. Increased demands made upon these departments for more public hunting, perennial crop depredation protection, and continued preservation of the waterfowl resource itself, preclude their funds covering all land management phases completely.

DEVELOPMENT OF HABITAT ON PRIVATE LANDS

Federal and state management areas cannot financially afford, at present, to meet all the necessary habitat requirements for waterfowl and should be assisted by land improvement practices by private land holders. A great many private areas in California are important wintering grounds but serve little to maintain waterfowl, as they are used almost exclusively for hunting. With the proper development of habitat, these properties could do a great deal to assist in the management of the resource. A program for the development of habitat improvement on private lands has been started in Wisconsin (Zimmerman, 1953). In this 1940-1943 survey of waterfowl habitat areas, some 102 lakes totaling 176,512 acres were checked.

In Minnesota a similar waterfowl habitat survey has been underway from 1946-1955. During this period some 1,300 lakes and marsh areas were surveyed, encompassing some 600,000 acres (Vesall, 1955).

The object of these two state-wide waterfowl habitat surveys has been to inventory ground conditions in order to recommend management improvement practices for improving private waterfowl areas.

In a Report to the Wildlife Conservation Board (Gordon, 1950), the idea was expressed that private clubs plant waterfowl foods. Probably the main objection to such plantings is the expense involved. Yet, some clubs now are engaged in such planting programs and others should be urged to do so. Certain arguments have been raised that only a few clubs have soils suitable for food raising. An examination of the soils throughout the Central Valley of California shows that practically all of the lands are capable of producing water grass (millet), sedges, some three-square bulrush, smart weed, certain pond weeds, and other food provided water is available. Water in California is the critical and necessary item during the late spring and summer seasons.

In California there are over 200,000 acres of land in the hands of about 1,000 private duck clubs. Many of these clubs could offer some needed assistance in the management of the waterfowl resource by the improvement of their habitat. Some clubs already have spent considerable sums of money on habitat improvement practices such as diking structures for water level control, food plantings both cultivated and natural, and the incorporation of mosquito abatement practices in conformity to State Public Health Codes. The results of some of these clubs' efforts have shown just reason for intensifying this program on private lands.

Below, in Figure 3, is shown a large portion of a 40-acre duck pond on the privately owned B and B Duck Club near Bakersfield, California. This pond was seeded in the late spring to black millet. This crop matured before the hunting season opened, and when flooded afforded an ideal habitat for ducks. In this pond some 25 acres of millet produced about 37.5 tons of waterfowl food. This variety of millet produces a heavier seed than the common millet of California. The open water area surrounds the blinds and affords a clear area for setting decoys and retrieving birds. Water control structures are set to maintain a constant water level to encourage further desirable plant growth and to drown out the undesirable ones.

Previously, it was mentioned that mosquito abatement practices were necessary in duck club management in California. The control of this insect menace is quite important to the vast population in that state, and various means of abating the insects are employed.

In general, good mosquito prevention practices on a duck club are also good habitat management for waterfowl. Some of these necessities are: (1) the elimination of aquatic seepage, (2) the employment of natural enemies of mosquitoes, *i.e.,* fish (*Gombusia affinis*), (3) constant water level flooding, and (4) vegetation-free levees at the water's edge. Abatement districts in California have

Figure 3. A portion of a 25-acre mature and flooded black millet crop on the B and B Duck Club near Bakersfield, California, in early October 1953. Photo by U. S. Fish and Wildlife Service.

shown that it is possible to control mosquitoes on duck clubs and refuges without damage to wildlife (California, 1951).

On private clubs the opportunity presents itself to develop a habitat for the benefit of the members and waterfowl together. Addy (1948) states that frequently plants are already present in a pond and need only proper water conditions to make them grow. He further relates that "plants growing in a matured habitat are generally the ones best suited to compete and survive in that particular place under existing conditions." It is the best then, in selecting plants for establishing a private waterfowl area, to choose those plants already growing in the area. Dr. Herbert Mason, a noted plant ecologist, confirms this by stating that duck foods can best be selected from those growing plants which have become established by natural selection.

SUMMARY

Agricultural land expansion brought about by increased reclamation and drainage projects has markedly reduced our natural waterfowl habitat. This loss of habitat is particularly critical in the Pacific Flyway. In general, the future of wetland habitat and hunting in

California are becoming more dependent on Federal and State waterfowl management areas.

To meet the problem of the rapidly decreasing natural waterfowl areas caused by expanding agriculture, corrective measures were taken by establishing Federal and State waterfowl management areas.

A program on these areas included the planting of cultivated and natural waterfowl foods along with proper water level manipulation. Proper timing of the crops' availability during the season for full utilization is important. Most cultivated crops produce more pounds per acre than natural foods.

The purchase and development of federal and state management areas are costly. Some six million dollars have been spent in California alone for capital outlay since 1949. Increasing operating costs of public wildlife agency lands limit their contribution to habitat development.

Federal and state waterfowl management area programs can be greatly assisted by the development of habitat on private lands. The benefit of private land developments will accrue to the owners, and our waterfowl resources, if certain fundamental land developmental procedures are followed. The employment of properly selected food planting and water level controls are paramount for successful development.

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DISCUSSION

MODERATOR WHITLOCK: This paper brings out a record of accomplishment. We do not have somebody here to ask the question as to how much it costs per duck. There are always those people who want to reduce everything down to the decimal point.

Has anyone any comments to offer on this paper? Of course, this business of preserving duck habitat or waterfowl habitat is getting more expensive. I don't like to talk about Michigan, but then I would like to say that a few years ago we bought some 2600 acres of marsh on Lake Erie at roughly a little less than $100 an acre, and everyone thought that was a lot of money. Three of four years ago we had a chance to purchase a small willow marsh next to this large one, something like 40 or 50 acres, and the price there was well over $100 an acre. This also included a clubhouse and we did not know how we were going to handle that clubhouse and the price being a little too much we did not do anything about it. Since that time the St. Lawrence Seaway has become a reality and a marsh just south of our 2600 acre marsh was sold here a little while ago. We had contemplated buying that marsh, but then it sold for about $900 an acre. What they are doing is buying all of this property on which to build factories, and this is something that we are going to continually be facing. What the solution is we do not as yet know. Of course, we have a couple of million dollars involved in this big marsh right now and we don't want to sell it but the thing that bothers us is whether or not we are going to be able to hang on to it.

MR. WALKER [Texas]: I would like to ask the speaker as to the cost per acre to produce, raise and harvest barley and other crops on this duckland after the land has been purchased and original developments have been made.

MR. LOSTETTER: The cost of the rice feed, which is usually purchased by our department, is about $5.00 a hundred-weight. The cost is about 70 cents a hundred to sow by airplane. The water costs vary in our locality. In one area it might cost 8 dollars an acre per season (and that is taken out of the ditch) and in other areas, where we have to pump it, it can cost up to about 14 dollars an acre per season.

DR. CONNOVER [Texas]: It seems to me that there is a lesson in this. I think that you saw those pictures of the flyway and if that area goes then you are going to chase away half of the wildlife and waterfowl resources of the Pacific Coast. I would just like to point out the importance of those few key areas, for without them, then your problems are going to skyrocket. This is serious and I think that the conservationists as a group should see that those areas are retained in public ownership.

MODERATOR WHITLOCK: Are there any other questions or comments? If not, I will turn this back to your chairman.

CHAIRMAN BISSELL: In closing this session may I congratulate each and every member of this group. A lot of cooperative effort and accomplishment has been summed up here. I am sure that many new guideposts have appeared for the benefit of all of us.

TECHNICAL SESSIONS

Monday Afternoon—March 5

Chairman: Louis A. Krumholz
Director, Lerner Marine Laboratories, Bimini, Bahamas

Discussion Leader: W. Harry Everhart
Chief, Fishery Research and Management, Department of Inland Fisheries and Game, Augusta, Maine

WETLANDS AND INLAND WATER RESOURCES

MEASURING HUNTING PRESSURE ON CANADA GEESE IN THE FLATHEAD VALLEY[1]

John J. Craighead
U. S. Fish and Wildlife Service, Missoula, Montana

and Dwight S. Stockstad
Montana State Fish and Game Department, Missoula, Montana

Waterfowl management on a continental scale involves preserving and managing aquatic habitat, making annual breeding ground inventories and winter population counts, and conducting intensive research on waterfowl species and populations. Information obtained and put into practice has been vital in setting waterfowl regulations throughout the flyways. The regulations evolved have steadily improved waterfowl hunting.

Data accumulated to date show that as the human population expands it becomes more and more difficult to increase or even maintain adequate waterfowl habitat, that the management of such habitat for migratory birds is costly and highly complex, that to effect a reduction in nesting losses or otherwise increase productivity is difficult except on protected areas and even there it soon reaches a point of diminishing returns. Management of the harvest, however, still

[1]Contribution from the Montana Cooperative Wildlife Research Unit; U. S. Fish and Wildlife Service, Montana State Fish and Game Department, Montana State University, and Wildlife Management Institute cooperating. The study was largely supported with Federal Aid in Wildlife Restoration funds under Pittman-Robertson Project W-71-R-1, the Montana State Fish and Game Department.

offers much room for improvement. Moreover, precisely managed waterfowl hunting in some areas appears to be a definite necessity in the future at the state, national, and international level.

Hickey (1955) points out the difficulties in controlling natural mortality and thoroughly discusses the biological basis of the hunter harvest. The hunter harvest probably lends itself to greater control and regulation by man than any other aspect of waterfowl management. Perhaps for this reason considerable effort has been expended to measure hunting pressure. Both Hickey (1955) and Elder (1955) have reviewed these efforts and the methods utilized. Rates of band recoveries and the use of a fluoroscope to detect the percentage of live ducks and geese carrying shot pellets have proved to be excellent techniques especially applicable to measuring hunting pressure on the major flyways (Hickey (1952), Cartwright and Law (1952), Whitlock and Miller (1947), Elder (1950) and Bellrose (1953)). A third approach used by Hansen and Smith (1950) was to obtain kill estimates of Canada geese (*Branta canadensis interior*) where the population could be accurately inventoried and to convert the kill into percentages of the winter population. A fourth approach applicable to harvest areas where there are local populations of Canada geese (*Branta canadensis moffitti*), and therefore of special significance to the western states, is to accurately inventory the breeding population, determine its productivity, census the late summer and early fall population and measure the kill and the hunting pressure exerted. The Montana Cooperative Wildlife Research Unit in cooperation with the P-R Division of the Montana State Fish and Game Department has been conducting a study of this type in order to determine the long term effect of hunting pressure on a local goose population. The kill or harvest can be expressed in two ways: First, the local geese killed during any given year can be expressed as a percentage of the breeding population; second, the entire harvest of both local and migratory birds can be expressed as a percentage of the average hunting season population level.

In the course of this study it became apparent that hunting pressure was the major mortality factor on Canada geese in Western Montana. This supports the conclusions of Hanson and Smith for Canada geese of the Mississippi Flyway (1950). However, hunting pressure, like predation pressure, is complex, and though such pressure has been measured by many competent scientists, there has been no thorough analysis of the dynamics of hunting pressure. It must be thoroughly understood before more effective regulations can be formulated. This paper will be devoted to discussing some factors affecting the harvest of Canada geese in the Flathead Valley and will specifically treat the relationships between goose numbers, goose movement, hunting pressure and goose kill. In other words we will attempt to evaluate human predatory pressure on a prey species, the Canada goose.

During autumn a large share of the nation's waterfowl are concentrated on state and federal waterfowl sanctuaries. In some instances limited shooting is allowed but generally birds become available to hunters only as they move in or out of the refuges. This situation exists at Ninepipe and Pablo Reservoirs in the Flathead Valley, Montana.

THE AREA

The Flathead Valley is approximately 50 miles long varying in width from 8 to 20 miles. It contains several large water areas which include Flathead Lake and four reservoirs, the most important of which are Ninepipe and Pablo, both federal waterfowl refuges. The Flathead River runs the length of the valley. All the water areas are important in the ecology of the geese, but in the fall of the year a large share of the goose population concentrates on the two refuges (Figures 1 and 2) and thus the areas immediately adjacent to the refuges offer good hunting.

Ninepipe Refuge has a land and water area of 2,032 acres with 1,582 surface acres of water at an elevation of 3,010 feet. The water can be reduced to 84 surface acres at an elevation of 2,991 feet.

Pablo Refuge contains a land and water area of 2,540 acres with 2,070 surface acres of water at an elevation of 3,210 feet. This can be reduced to 260 surface acres at an elevation of 3,186 feet.

Ninepipe contains 14,870 usable acre feet of water when full and Pablo 27,100.

PROCEDURE

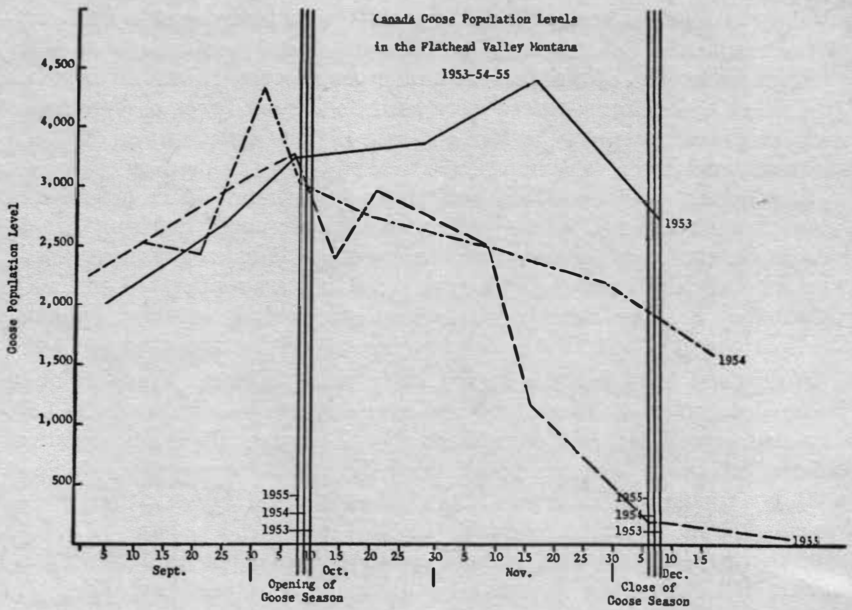
In 1953, 1954, and 1955, hunting pressure on Canada geese and goose kills were measured throughout the entire Flathead Valley by means of field checks and hunter interviews during every day of the 60-day seasons. In addition Ninepipe and Pablo Reservoirs were selected for intensive study, zoned and observers assigned to specific stations to record goose movements as well as goose kills and hunting pressure. Ninepipe had three stations with an observer assigned to each station. Pablo had two stations and two observers. The areas were zoned in such a way that complete and continuous daily observations could be made. Each observer covered a designated area recording goose movements in and out of the refuges, tallying geese killed and crippled and recording hunting pressure in terms of hunter hours. Data were taken on form sheets and tabulated and cross checked with all observers at the end of each day. All goose movement in and out of the respective refuges could be observed from the stations as well as most movement of hunters to and from shooting pits and blinds. The killed and crippled geese were recorded from direct observations and later confirmed by hunter interview. The date, place of kill, and name of hunter were recorded for every goose bagged or crippled so there would be no possibility of confusion when field records were later checked against hunter interviews. Designated parking areas and check stations facilitated the recording of hunter pressure. Private shooting clubs and the intensive goose hunters cooperated enthusiastically in keeping records which were periodically checked against the field observations. Form sheets were issued for this purpose.

During the 1954 hunting season, data were taken on Ninepipe and Pablo Reservoirs on 15 and 14 weekend days respectively of the 60-day season and six and four week days. During the 1955 hunting season, data were taken on 18 weekend days at both reservoirs during a 60-day season. No data was taken on week days. Observations were recorded from daylight to dark. In 1954 and 1955 a total of 3,454 man hours were expended in field activities and 1,040 in 1953. Thus during three hunting seasons, 4,500 man hours were expended to obtain the data on goose numbers, movements, kill and hunting pressure presented in this paper.

POPULATION LEVELS

The Flathead goose population is relatively small and therefore could be quite accurately censused. Periodic aerial censuses were made of geese throughout the entire Flathead Valley from late summer until after the close of the hunting seasons. Both aerial and ground counts were made simultaneously at Pablo and Ninepipe Reservoirs during 1953, 1954 and 1955. Data on the nesting populations and their productivity (Geis, in press) supplemented with band returns and sight records of color marked birds showed that the hunting season goose population in the Flathead Valley was composed largely of local birds.

Figure 1 shows that during the three years of study, each hunting season opened with the goose population at 3,000 to 3,300 birds; but that this was followed by marked variations in population levels for the three years. In 1953 a steady increase in goose numbers occurred until after mid-season. Then followed a slight decline. The population level remained generally high throughout the hunting season. In 1954 a steady decline occurred but there were still about 2,000 geese in the valley at the close of the season. The 1955 population remained high until about mid-season, then suddenly dropped to a



Note: Ground and aerial censuses.

Figure 1

low level of 178 birds by December 6th. The average hunting season population figures for the entire Flathead Valley of 3,320, 2,613, and 2,127 for 1953, 1954, and 1955 respectively fairly accurately represent the hunting potential. A comparison of population levels throughout the valley (Figure 1) with those at Pablo and Ninepipe Reservoirs (Figure 2) shows that most of the geese in the Flathead Valley concentrate on the two reservoirs during the hunting season and it is there the heaviest hunting occurs. The fall goose population consisted of both local and migratory geese, but at no time did migratory geese comprise more than 50 per cent of the populations and during the greater portions of each season resident birds comprised the largest segment of the respective populations.

RELATION OF GOOSE KILL TO GOOSE NUMBERS

Figure 2 shows the relationships during three consecutive years of the kill (killed and crippled) of Canada geese to goose numbers or population levels. A direct relationship exists between the magnitude of the kill and the number of geese for two out of three years. However, the exception shows the smallest goose kill was made in 1953 when the highest population level prevailed. This inverse relationship of kill to goose numbers can be explained almost entirely by the fact that during the 1953 hunting season the reservoirs were at extremely low water levels. Ninepipe contained 84 surface acres of water as compared to 964 and 438 in 1954 and 1955 respectively. Pablo contained 260 as compared to 932 and 571 in the other years. The mud flats exposed at low water levels offer ideal feeding areas. Thus food was abundant and readily accessible on both refuges and as a result, goose feeding flights in and out of the areas were greatly reduced. Only 9 per cent of the average population level for the season moved

Relation of Goose Kill to Goose Numbers
Ninepipe and Pablo Reservoirs
1953-54-55

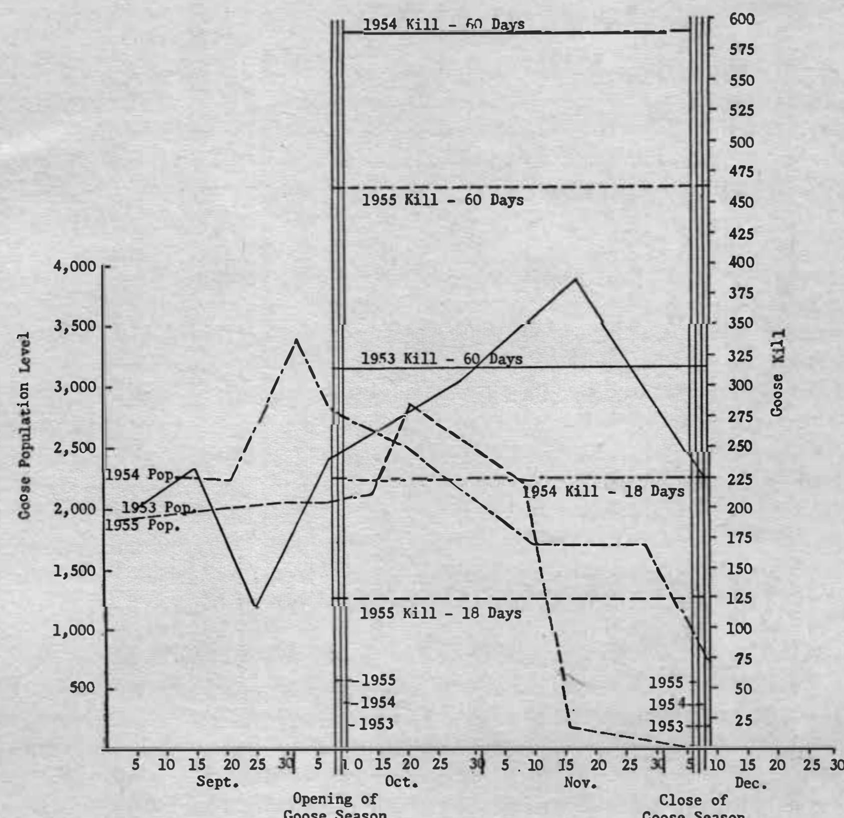


Figure 2

TABLE 1. GOOSE MOVEMENT AND KILL RELATED TO HUNTING PRESSURE

	Ninepipe Reservoir — 1954 & 1955[1]								Pablo Reservoir — 1954 & 1955[2]							
	Area 1		Area 2		Area 3		Area Total		Area 1		Area 2		Area Total		All Areas	Killed and crippled
	1954	1955	1954	1955	1954	1955	1954	1955	1954	1955	1954	1955	1954	1955	1954-1955	
Total No. flights	260	104	266	111	179	74	705	292	274	46	199	277	473	323	1,793	
Total No. of geese flying	3,765	1,653	4,663	1,905	2,298	1,086	10,726	4,644	3,768	658	2,965	3,355	6,733	4,013	26,116	
No. flights during shooting hours	217	99	212	105	161	68	590	272	258	46	185	270	443	316	1,621	
No. of geese flying during shooting hours	3,253	1,582	3,707	1,767	2,069	945	9,029	4,294	3,518	658	2,741	3.226	6,259	3,884	23,466	
No. of flights over hunters	39	25	102	48	50	39	191	112	116	28	98	81	214	109	626	
No. of geese over hunters	758	401	1,895	685	611	536	3,264	1,622	1,470	410	1,307	860	2,777	1,270	8,933	
% of flights over hunters during shooting hours	18.0	25.3	48.1	46.7	31.1	57.4	32.4	41.2	44.9	60.9	53.0	30.0	48.3	34.5	38.6	
% of geese flying over hunters during shooting hours	23.3	25.4	51.1	38.8	29.5	57.7	36.2	37.8	41.8	62.3	47.8	26.7	44.4	32.7	38.1	
No. of geese killed	15	11	20	35	30	16	65	62	60	25	18	17	78	42	247	308
No. of geese crippled	3	1	9	8	7	3	19	12	12	2	8	8	20	10	61	
% kill of geese moving over hunters during shooting hours	1.97	2.74	1.05	5.10	4.90	2.98	1.99	3.82	4.08	6.09	1.37	1.97	2.80	3.30	2.8	3.4
% kill of all geese moving during shooting hours	0.46	0.69	0.54	1.98	1.44	1.69	0.71	1.44	1.70	3.79	0.65	0.52	1.24	1.08	1.1	1.3
No. of geese moving before and after shooting hours	512	71	956	138	229	141	1,697	350	250	....	224	129	474	129	2,650	
% of geese moving before and after shooting hours	13.6	4.3	20.5	7.2	10.0	13.0	15.8	7.5	6.6	....	7.6	3.84	7.0	3.21	10.1	
No. of hunters	240	195	310	326	395	304	945	825	1,149	693	339	201	1,488	894	4,152	
No. of hunter hours	466	470	601	848	998	903	2,066	2,221	2,993	2,408	1,264	696	4,259	3,104	11,650	
Ave. No. of hunter hours per goose killed (hunter success)	31.1	42.7	30.0	24.2	33.3	56.4	31.8	35.8	49.9	96.3	70.2	40.9	54.6	73.9	38	
Ave. No. of hours per hunter															2.81	

[1]Measured on Weekends only: 15 days in 1954 and 18 days in 1955.
[2]Measured on Weekends only: 14 days in 1954 and 18 days in 1955.

each day. Relatively few targets were presented to hunters in spite of a large concentration of geese. This situation suggested the importance of goose movement as a factor in harvesting geese and detailed movement data were taken in following years.

The 1954 population level was generally higher than in 1955 and the kill greater (Figure 2). In 1955 a severe cold period beginning November 11th froze the reservoirs over night forcing the geese to leave. In less than a week the population dropped from 2,200 to less than 200. Most of these geese moved completely out of the valley. It is significant that the total of recorded kills for the 60-day seasons of 1954 and 1955 and the kills for weekend days on which movement was taken (Table 1 and Figure 2) all show a direct relationship to goose numbers.

When kill data and goose numbers for 1953 are plotted separately for Pablo and Ninepipe, as shown in Figure 3, a direct relationship between goose numbers and size of kill is evident.

In 1954 there was again a direct relationship between population size and goose kill on both reservoirs for those days on which movement, kill, and hunting pressure were measured (Figure 4).

In 1955 an inverse relationship existed, the greater kill being obtained from the smaller population (Figure 5). This can be explained on a basis of goose movement and will be discussed later.

Tables 1 and 2 show that during both 1954 and 1955 more geese flew at Ninepipe than at Pablo in spite of the much higher population

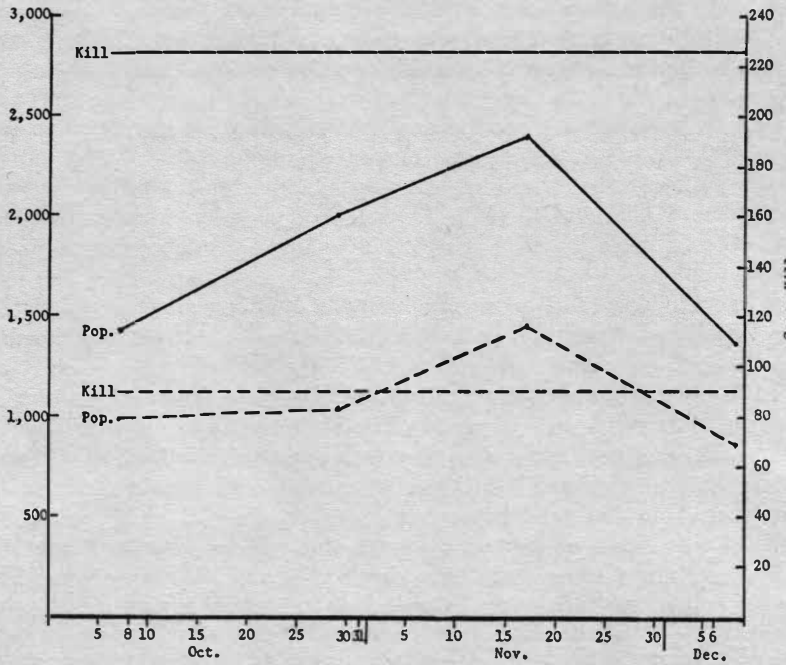
TABLE 2. GOOSE MOVEMENT AND KILL RELATED TO HUNTING PRESSURE AT PABLO AND NINEPIPE RESERVOIRS—1954

Measured on 4 and 6 Week Days Respectively During the Hunting Season

	Ninepipe Reservoir Area Total	Pablo Reservoir Area Total	Total Both Reservoirs	
Total number flights	186	125	311	
Total number geese flying	3,450	1,927	5,377	
Number of flights during shooting hours	169	119	288	
Numbers of geese flying during shooting hours	3.095	1,817	4,912	
Number of flights over hunters	40	40	80	
Number of geese over hunters	586	562	1,148	
% of flights over hunters during shooting hours	23.7	33.6	27.8	
% of geese flying over hunters during shooting hours	18.9	30.9	23.4	
Number of geese killed	27	17	44	56
Number of geese crippled	1	11	12	
% kill of geese moving over hunters during shooting hours	4.60	3.92	3.83	5.00[1]
% kill of all geese moving during shooting hours	0.87	0.93	0.90	1.14[1]
No. of geese moving before and after shooting hours	355	110	465	
% of geese moving before and after shooting hours	10.3	5.7	8.6	
Number of hunters	116	161	277	
Number of hunter hours	323.75	655.25	979.0	
Average number of hunter hours per goose killed (hunter success)	12.0	38.5	17.5	
Average number of hours per hunter	....	....	3.5	

[1]Per cent killed and crippled.

Relation of Goose Kill to Goose Numbers
at Pablo and Ninepipe Reservoirs
Entire 1953 Hunting Season



______ Kill and population level - Pablo Reservoir
------- Kill and population level - Ninepipe Reservoir

Note: Population levels based on 4 aerial counts and 4 supporting ground counts at each refuge.

Figure 3

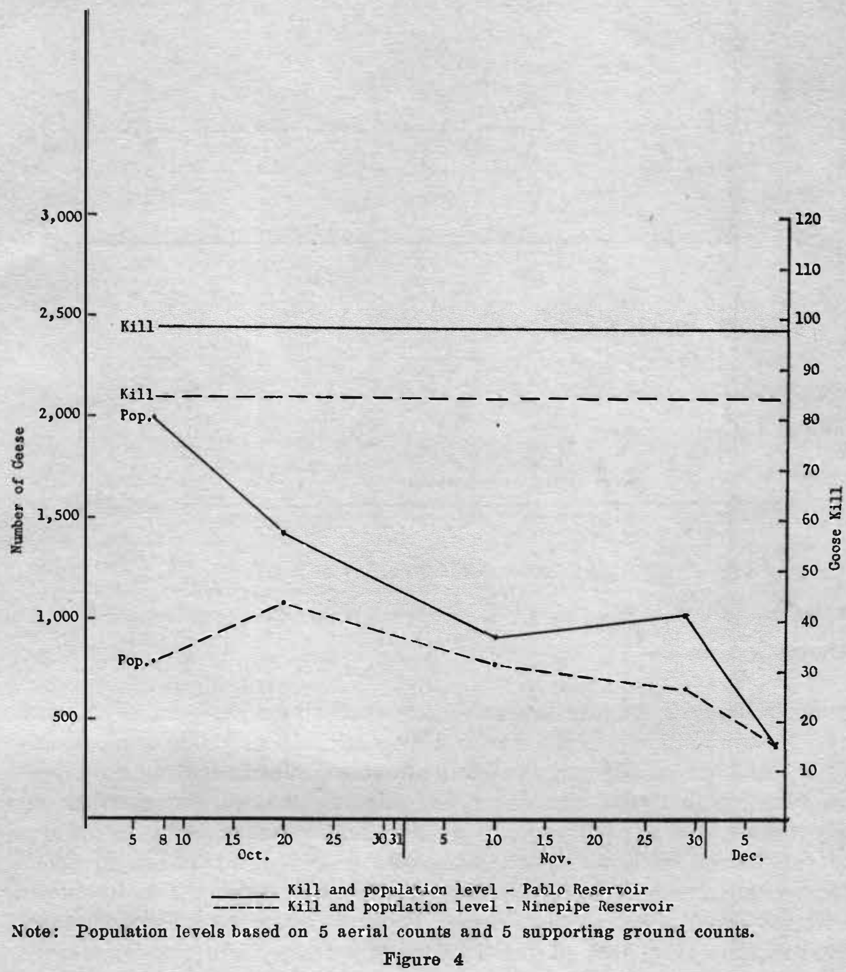
levels at Pablo. Also more of these geese passed over hunters. There was, however, less hunting pressure at Ninepipe than at Pablo, these values being 2,066 and 4,259 hunter hours respectively for 1954 and 2,221 and 3,104 for 1955. The lack of movement at Pablo counteracted the density relationship. In spite of more geese present fewer targets were presented to hunters. At Ninepipe during the former year the average number of hunter hours per goose killed was 31.8 while at Pablo it was 54.6. In 1955 these values were 35.8 and 73.9.

We can conclude that generally there tends to be a direct relationship between goose numbers and goose kill but that movement can completely alter this density relationship.

RELATION OF GOOSE MOVEMENT TO GOOSE NUMBERS

In 1954, 1,489 goose flights were observed at Ninepipe and Pablo Reservoirs during 21 and 18 days respectively of the 60-day season. This included both week days and weekend days. These flights composed a total of 22,836 geese moving over hunting areas. We should expect to find a direct correlation between movement and numbers of

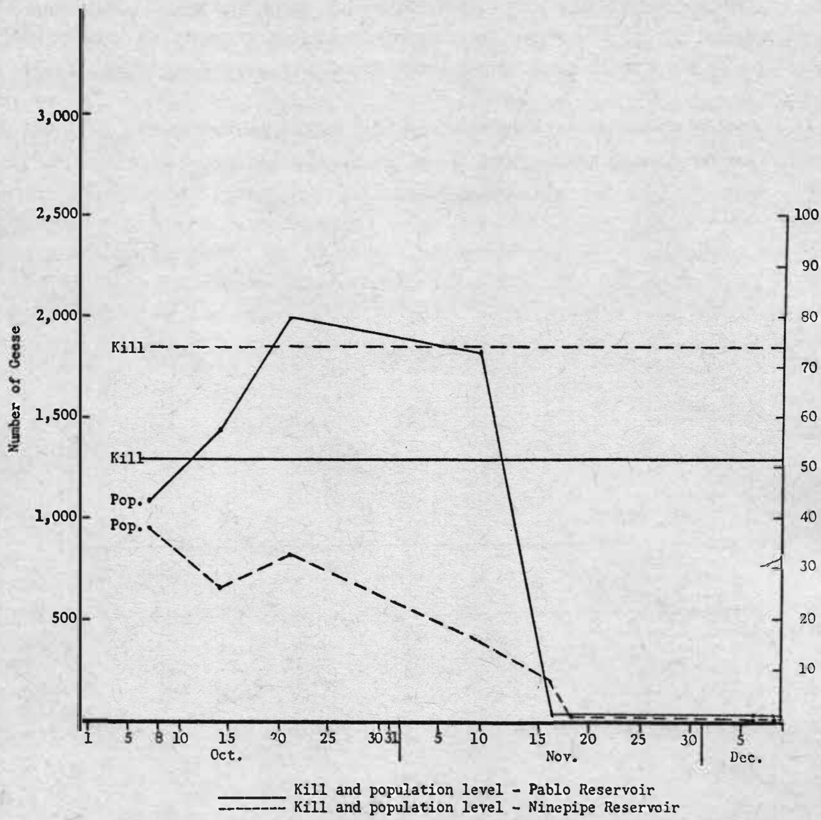
Relation of Goose Kill to Goose Numbers at Pablo and Ninepipe Reservoirs
for Days on which Movement, Kill, and Hunting Pressure were Measured
1954 Hunting Season



Note: Population levels based on 5 aerial counts and 5 supporting ground counts.

Figure 4

Relation of Goose Kill to Goose Numbers at Pablo and Ninepipe Reservoirs
for Days on which Movement, Kill and Hunting Pressure were Measured
1955 Hunting Season



Note: Population levels based on 7 aerial counts and 6 supporting ground counts.

Figure 5

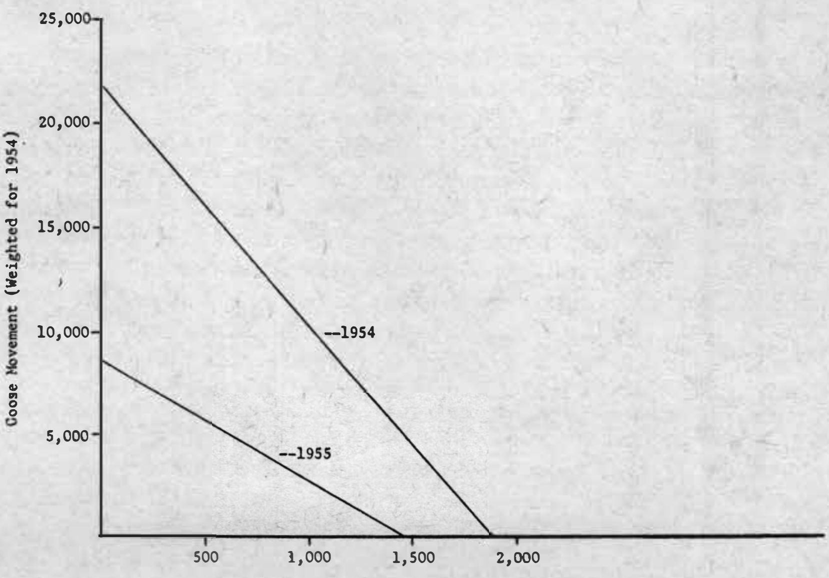
geese. However, Figure 6 shows little correlation between movement and goose numbers when data for 1954 and 1955 are compared. Complete data for 1953 is not available but there appeared to be even less relationship between the degree of movement and the number of geese then, than in subsequent years. Furthermore, analysis of observations of movement for Ninepipe in 1954 and Pablo in 1955 showed no correlation between the number of geese in the two refuges and the number of geese moving (Figures 7 and 8). For example, during the early part of the 1954 season there were approximately

1,000 geese on Ninepipe and generally less than half this number were recorded as daily moving in and out of the refuge. Towards the end of the season when between 500 and 700 geese were present, over 150 per cent were recorded as moving. Thus the number of geese available as targets to hunters was considerably greater when the population level was low than when it was high. The ground and aerial censuses showed an average of 1,890 geese present in Ninepipe and Pablo Reservoirs during the hunting season. The tallies of movement for weekends and week days combined showed an average of 1,036 geese daily flew in and out of the refuges during shooting hours. Thus the geese moving in such a way as to present themselves as targets to hunters (within shooting distance) represented an average of 55 per cent of the average number of geese present during the season. This is in contrast to 10 per cent for 1953. Each record of a goose moving does not represent an individual goose. Some days dur-

Relation of Goose Movement to Goose Numbers

(Reservoir Data Combined)

1954-1955



Note: Average populations based on five censuses made on comparable dates.

Figure 6

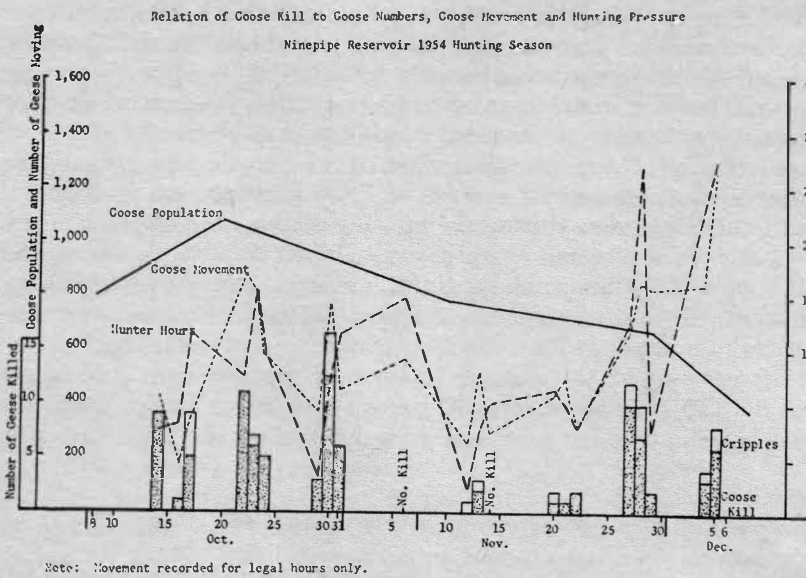


Figure 7

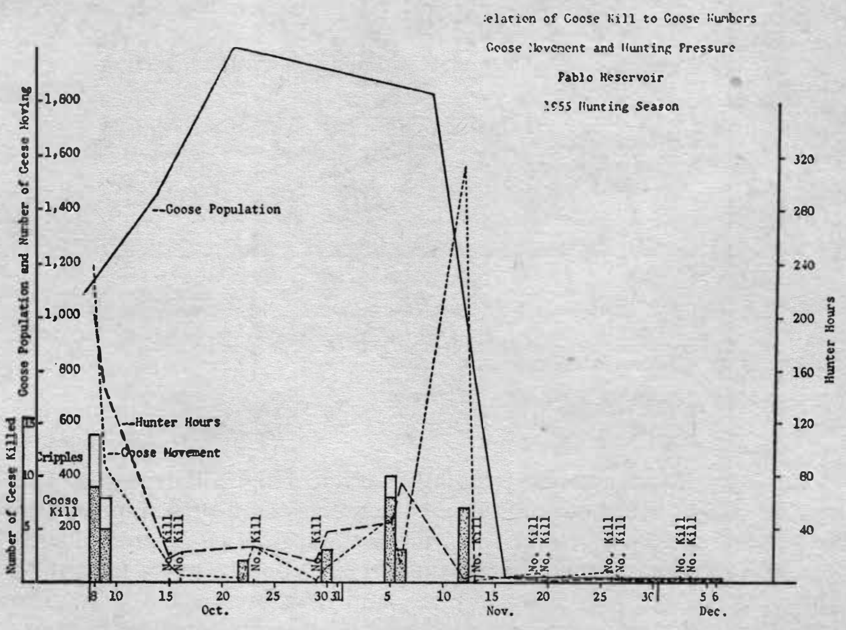
ing the 1954 season over two and a half times as many geese were observed moving as were known to be in the area. On the average, each goose presented itself as a target two and a half times during those days. A similar situation existed in 1955. At the opening of the season (Figure 8) as many geese moved as were known to be on Pablo Reservoir. Movement then dropped tremendously until mid-November when again movement equalled or exceeded the number of birds present. The number of geese moving in and out of the refuges rather than the total number of geese present, represented the potential shooting. Under favorable water and weather conditions, relatively few geese can have a high target value providing they move over shooting areas frequently. Conversely, large numbers of geese can have a low target value if they do not move regularly and frequently.

Data presented in Figure 9 is particularly interesting. It compares the movement of geese at Ninepipe during 1954 and 1955 with movement at Pablo during these same years. In 1954 the average population level at Pablo was considerably greater than at Ninepipe, these values being 1,151 and 739 respectively; yet the movement of geese at Ninepipe was greater than at Pablo, these values being 10,726 and 7,214 respectively. During 1955, Pablo on the average contained twice as many geese as Ninepipe (Figure 9) yet there was less movement of geese at Pablo. Thus during both years the degree of movement in relation to numbers was much greater at Ninepipe. One factor accounting for this is that more food is available on the Pablo refuge, but other factors as yet unknown may be important.

It is evident that movement as well as sheer numbers may have an important bearing on the number of geese harvested. As Table 1 shows, 158 geese were killed or crippled at Ninepipe compared to 150 at Pablo during both years. This in spite of the fact that both population level and hunting pressure were greater at Pablo. The disproportionate kill can be explained almost entirely on the basis of goose movement.

Figure 7 shows the relationship of goose movement to population level during weekends and week days at Ninepipe in 1954. Figure 8 shows this relationship for Pablo during weekends of 1955.

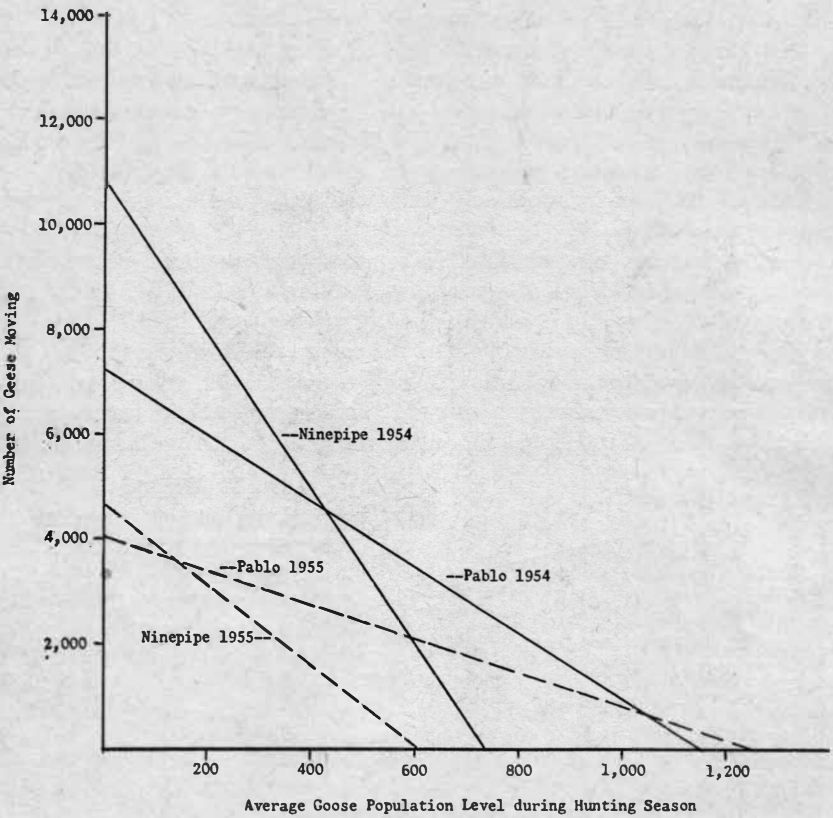
The tallies of movement (Table 1) show that 26,116 geese moved in and out of Ninepipe and Pablo during 1954 and 1955, on the weekend days when movement was recorded. This represents an average of 800 geese that daily flew in and out of the refuges. Ground and aerial



Note: Movement recorded for legal hours only.

Figure 8

Relation of Goose Movement to Goose Numbers
on Pablo and Ninepipe Reservoir
1954-1955



Note: Movement measured during 15 days in 1954 and 18 days in 1955.
Pablo data for 1954 weighted.

Figure 9

counts showed an average population level of 2,370 during the two seasons. Thus the geese presenting themselves as targets represented an average of 34 per cent of the average number of geese present during both seasons. There is a tremendous variation in goose movement from day to day, from place to place, and from season to season. The importance of movement as a factor in determining harvest is strikingly evident.

Relation of Goose Kill to Goose Movement

at Pablo and Ninepipe Reservoirs

1954-1955

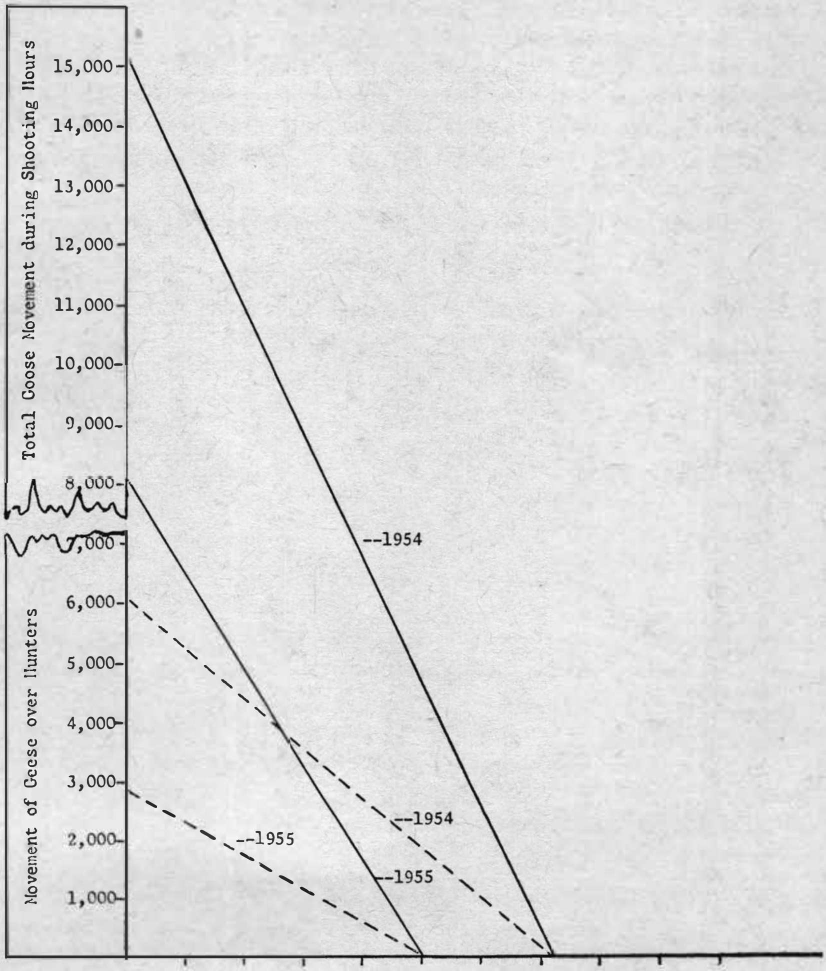


Figure 10

RELATION OF KILL TO MOVEMENT

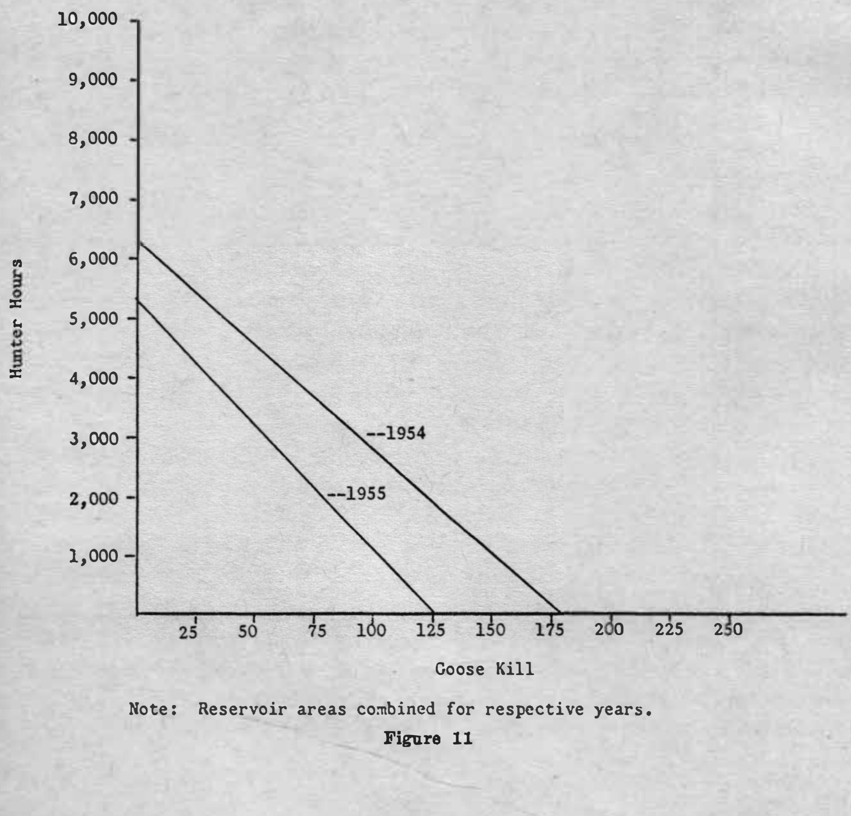
A direct relationship exists between the number of geese killed and crippled and the number of geese moving. Figure 10 shows that in 1954 with a movement of over 15,000 geese in and out of the two refuges during 29 recording days, 182 geese were killed and crippled. In 1955 with over 8,000 geese moving, 126 were killed and crippled. A similar relationship exists between the number of geese moving over hunters and the number of geese killed (Figure 10).

This same relationship holds true for both Ninepipe and Pablo Reservoirs when the data for these are evaluated separately. One specific example will suffice to show the general trend. On October 23, 1954, approximately 1,300 geese were on Pablo; 1,246 geese or 95 per

Relation of Goose Kill to Hunting Pressure

at Pablo and Ninepipe Reservoirs

1954-1955



Note: Reservoir areas combined for respective years.

Figure 11

cent moved to and from the Reservoir. One hundred and twenty-three hunters took 28 birds. A day later, October 24th, with approximately the same number of geese present, only 281 geese or 22 per cent moved. One hundred and twenty-four hunters (a hunting pressure equal to the preceding day) accounted for only 4 geese.

Figure 7 shows the relationship of kill to movement at Ninepipe during the 1954 hunting season. Through October an increase in movement invariably resulted in an increased kill. In November there were two exceptions to this trend. However, at the close of the season with the population level dropping steadily, goose movement increased to such an extent that approximately three times as many geese were recorded moving as there were individuals on the refuge. As a result the goose kill remained comparable to early season kills when the population level was much higher.

We can thus further confirm the importance of movement in determining kill. It can completely reverse the normal density relationship of goose kill to population level that we have earlier shown exists. A high population level with little movement results in a proportionately small kill; whereas a low population level with great movement results in a proportionately large kill. There are, of course, many intergradations between these extremes as Figure 7 and 8 illustrate.

RELATIONSHIP OF KILL TO HUNTING PRESSURE

A third factor directly affecting the goose kill is hunting pressure. Table 1 summarizes the hunting pressure data obtained on Ninepipe and Pablo for weekend days of 1954 and 1955. During these two hunting seasons, 4,152 hunters exerting a total pressure of 11,650 hunting hours for an average of thirty-two and a half days each season accounted for 308 geese killed and crippled. This represents one goose killed for every 38 hunter hours. To bag these geese each hunter spent an average of 2.8 hours and an average of one goose was killed or crippled for every 13 hunters.

Of the geese moving over hunters during shooting hours, 3.4 per cent were killed and crippled whereas only 1.3 per cent of all geese moving during shooting hours were killed or crippled.

Figure 11 shows a direct relation between the number of geese killed and crippled and the number of hours spent hunting geese. The relationship between hunting pressure and kill is also evident from Figures 7 and 8. This is graphically shown for Ninepipe Reservoir during the 1954 hunting season and for Pablo during 1955 but it is typical of the situation for both reservoirs during both years. In general heavy kills occurred when hunting pressure was heavy. Low hunting pressure coinciding with a high population level, increased movement or both, generally did not result in a heavy kill. There were, however, exceptions to this rule. We can conclude that the magnitude of the hunting pressure is a vital factor determining the kill.

RELATION OF KILL TO GOOSE NUMBERS, GOOSE MOVEMENT, AND HUNTING PRESSURE

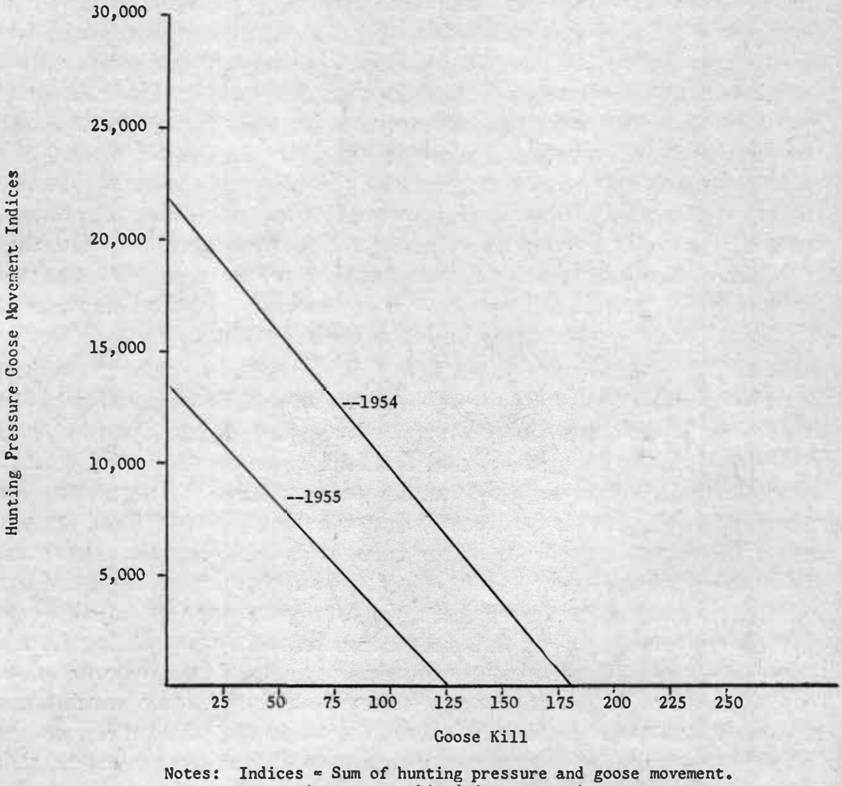
It has been shown that direct relationships exist between the number of geese killed and the goose population level, the movement of geese and the amount of hunting pressure exerted. It is evident from Figures 7 and 8 that any one of these three major factors affecting goose kill can be controlling depending on circumstances. In general the size of the goose population and the magnitude of the hunting pressure are basic. However, movement can alter the relationships in such a way as to at times completely reverse the density relationships of goose kill to goose numbers or goose kill to hunting pressure. Both goose movement and hunting pressure can be manipulated through management practices and it is important to note that when indices were formed by adding the values obtained for hunting pressure and goose movement for 1954 and 1955 and plotting the combined values against the kill for those years, it showed an almost perfect straight line relationship (Figure 12).

RELATIONSHIP OF GOOSE MOVEMENT TO HUNTING PRESSURE

A common belief among local goose hunters is that geese soon learn where hunting pressure is great and contrive to leave the reservoirs through corridors where shooting is light or where hunting is prohibited or impossible due to physical barriers. On Ninepipe there were two corridors, one to the east and one to the west where geese could leave the refuge and attain considerable height before reaching a point where hunters could shoot at them. Movement data showed that relatively few flocks utilized these corridors and that probably no geese learned these flight lanes were relatively safe. Certain flocks followed well defined flight patterns day after day in spite of formidable arrays of guns and men. Various flocks went to certain feeding and loafing areas and the general direction in which these lay appeared to determine the direction of flight.

In general, geese flew higher on clear days and as the season advanced, but this relation was not entirely consistent. Many low level flights occurred late in the season and went directly over areas of heavy hunting pressure. There was an excellent example of this at Pablo during 1953. One hundred and seventy-five geese were killed

Relation of Goose Kill to Hunter Pressure Goose Movement Indices
at Ninepipe and Pablo Reservoirs—1954-1955



Notes: Indices = Sum of hunting pressure and goose movement.
Reservoir areas combined for respective years.

Figure 12

from a consistent local flight of about 300 geese that flew from Pablo Refuge to Flathead Lake in the evening, spent the night, returning to the refuge in the morning. The banded geese shot from this flight had all been banded at the West Polson Bay rearing grounds, the destination of the birds when they left the refuge. The persistence of the flight and the fact that between 50 and 200 of the geese were reared at Polson Bay in 1953 suggests a strong attachment for the rearing areas. This flight continued throughout the season in spite of the fact that approximately 60 per cent of the birds were killed. The flight was subjected to greater hunting pressure than any other segment of the population.

Geese were attracted to Pablo and Ninepipe Refuges long before the opening of the hunting seasons. By August many adults and immatures are gathered there. In 1954, 70.6 per cent of the entire valley population was concentrated there by mid August. In 1955, 83.4 per cent were tallied within the two refuges in early September. After the first week of hunting the birds react to the protection of the refuges by confining more of their activities to the areas, but during the three years of study there appeared to be no direct correlation between the daily movement of geese and the magnitude of hunting pressure. There is little doubt that hunting pressure restricted movement of geese, but it did not have a controlling effect on movement. Biological drives appeared to be far more important.

Another staunchly defended belief is that many geese move just prior to and just after shooting hours. Table 1 shows that in 1954 and 1955, 26,116 geese were recorded as moving at Ninepipe and Pablo during shooting hours and for half hour periods prior to and after shooting hours. Of this number only 2,650 or 10 per cent were recorded as moving before and after shooting hours. Thus 90 per cent of the geese moved out of the refuges as legal targets. However, the hunters have a legitimate "gripe" when they claim the geese are moving everywhere but over their pits. Only 38 per cent of all geese moving were recorded as flying over hunters during shooting hours. There is little evidence that this is due to learned behavior or goose intelligence but rather to the fact that on any given day hunters are so distributed that geese can leave without flying within range. As hunting pressure increases, the percentage flying over hunters will also increase. On some days when hunting pressure was great, between 50 and 70 per cent of the moving geese flew over hunters. It is apparent that goose movement is not something readily correlated with other factors. This we should expect. Geese being what they are, the frustrating question facing every goose hunter of where to make his stand to get some shooting, is likely to remain as frustrating as ever. That's what makes goose hunting a sport.

OTHER FACTORS DETERMINING GOOSE KILL

We have presented the major factors determining the kill of Canada geese in the Flathead Valley and attempted to show how these factors are related. There are some minor factors operating within the controlling effect of these basic ones that should be considered. Although not fundamental, they have an important bearing on how and when the harvest is taken and some of them could conceivably be more controlling in other situations.

We could find no significant relation between daily local movement of geese in and out of the refuges and weather conditions. Some of the largest movements occurred on warm sunny days and conversely there was little movement on some of the cloudy or stormy days. However, as every goose hunter knows, weather affects goose hunting. It plays an important role on migratory flocks in the Mississippi Flyways, Hanson and Smith (1950) and Jahn, Gunther, and Bell (1954). In the Flathead Valley the approach of a storm front or a rapid drop in temperature brought migrant geese into the valley and moved others out. This generally affected the kill, but it was difficult to accurately measure.

The effect of weather on goose numbers through migratory movements was evident during all three years of the study but is best exemplified by what occurred on November 11, 1955. It snowed heavily all day with the temperature dropping steadily. No precise movement data was recorded but practically every goose on Ninepipe left before evening. The temperature continued to drop, reaching a low of —10° F. on the morning of November 12. All but a small portion of the reservoir was frozen and not a single goose remained. The same thing occurred at Pablo where the population dropped from over 2,800 to approximately 200 within 48 hours. These movements involved both resident and non-resident geese.

Visibility conditions and the skill and experience of the hunters to a large extent determine the effectiveness of hunting pressure. On Horicon Marsh, large kills were always registered on foggy mornings when the hunters could not see the birds (and vice versa) until they were in killing range, Jahn, Gunther, and Bell (1954). A similar trend was evident at Ninepipe and Pablo.

The quality of the hunting pressure has an important bearing on the magnitude of the kill and is a factor to consider in management. The weekend hunters in the Flathead Valley were largely novice goose hunters, while those hunting during week days were largely intensive hunters with years of goose hunting experience behind them. Many of the latter took vacations during the waterfowl season, hunted geese day after day, studying goose movements, weather and food conditions. A considerable number belonged to shooting clubs bordering the refuges. Such conditions facilitated hunting. These hunters invariably had excellent equipment, were good shots and possessed the patience and stamina necessary for successful goose hunting. These intensive hunters not only hunted throughout most of the season, but they also were on hand season after season. The novice hunters were quite a different breed. In 1955, for example, 646 hunters of 993 interviewed were hunting geese for the first time. Only 347 were recorded as hunting in both 1954 and 1955.

A comparison of Table 1 with Table 2 shows the difference in quality of hunting pressure on week days as compared to weekends during 1954 and 1955. The per cent of goose flights and geese flying over hunters during shooting hours was significantly less during week days than weekends. This was because fewer hunters were out. The average number of geese moving was not significantly different. The per cent kill of geese moving over hunters during shooting hours, however, was 1.99 on weekends and 3.83 on week days. Similarly the average number of hunter hours per goose killed was 31.8 on weekend days and 17.5 on week days. The marked difference in hunter success was due to the increased percentage of experienced hunters. On weekends 3.4 per cent of all geese flying over hunters were killed or crippled, on week days 5.0 per cent were killed or crippled.

The quality of the hunting pressure can be readily evaluated from Tables 3 and 4. An effort was made to contact every goose hunter known to have hunted anywhere in the Flathead Valley. In 1954, 975 hunters were interviewed. Of this number 357 or 36.5 per cent were checked from one to many times in the field and then interviewed after the close of the season in order to obtain a complete record of geese killed and crippled and number of days and hours hunted. All field data were cross checked against the post-season interview data. Those hunters from whom complete data were obtained, hunted a total of 3,025 days, comprising 15,233 hunter hours, and killed 433 geese and crippled 80.

In 1955, 993 hunters were interviewed; 414 or 41.7 per cent were checked in the field and by post-season interview. The 414 hunters whose records were complete hunted a total of 2,101 days, comprising 13,476 hunter hours, and killed 509 geese, crippling another 68.

The distribution of kill among the hunters is revealing. Table 3

TABLE 3. DISTRIBUTION OF GOOSE KILL
Flathead Valley—1954

No. of Hunters	% of Total Hunters	No. of Geese Killed	% of Total Geese Killed
1	.28	24	5.54
3	.84	70	16.17
4	1.12	84	19.40
5	1.40	95	21.94
7	1.96	115	26.56
8	2.24	124	28.64
13	3.64	164	37.88
16	4.48	185	42.73
18	5.04	197	45.50
22	6.16	217	50.12
30	8.40	249	57.51
46	12.89	297	68.59
76	21.29	357	82.45
152	42.58	433	100.00
357	100.00	433	100.00

TABLE 4. DISTRIBUTION OF GOOSE KILL
Flathead Valley—1955

No. of Hunters	% of Total Hunters	No. of Geese Killed	% of Total Geese Killed
1	.24	19	3.73
3	.73	49	9.63
4	.97	60	11.79
7	1.69	90	17.68
10	2.42	117	22.99
12	2.90	133	26.13
14	3.38	147	28.88
17	4.11	165	32.42
31	7.49	235	46.17
46	11.11	295	57.96
67	16.18	358	70.33
103	24.88	430	84.48
182	43.96	509	100.00
414	100.00	509	100.00

shows that in 1954 one hunter accounted for 24 geese, and that a relatively few hunters took a large share of the total kill. For example 22 hunters or 6.16 per cent killed 217 geese or 50 per cent of the total bag. Over half the hunters were unsuccessful in killing a goose.

Table 4 shows a similar situation in 1955. One hunter killed 19 geese, 3 killed 49; 4 killed 60; and 31 hunters or 7.49 per cent shot 235 geese representing 46 per cent of all the geese bagged. Again over half the hunters closed the season without a goose.

The role of the intensive and experienced goose hunter in the harvesting of the Flathead Valley geese must be considered in future management.

THE HARVEST

In 1953, 1954, and 1955 a minimum of 365, 645, and 751 geese were bagged by hunters in the Flathead Valley during the respective hunting seasons. The banded kill of locally banded birds was 43, 57, and

79 for those years. These banded kills represented 20.7, 13.6, and 20.7 per cent respectively of the populations banded each year. In 1953 resident birds composed 80 per cent of the total known kill. During the following two years resident birds comprised 33.2 and 49.4 per cent of the total bag (computed on a basis of banded kill in the year of banding only). The exceptionally high kill of resident birds in 1953 was due largely to the excessive hunting pressure exerted on the Pablo-Polson Bay goose flight discussed earlier.

The number of geese known to have been killed and crippled for each of the three hunting seasons was 485, 764, and 822. This represents only those that could be definitely substantiated by field check and hunter interview. Thus in 1953, 14.6 per cent of the average hunting season population was killed and crippled. In 1954 and 1955 these values were 29.2 and 38.6.

From data at hand we could compute the percentage of the resident goose population annually killed and crippled. To have most significance such data should be compared with the reproductive capacity of the local goose population and this lies beyond the scope of the present paper.

Suffice it to say that it is too early in the study to determine whether the resident population can bear a heavier harvest or whether a reduction in the kill would be desirable. The fact that the nesting population has slowly increased during the past three years would indicate the resident population can support the current hunting pressure and kill. Nevertheless there appears to be little doubt that more precise management of the harvest will be necessary in the future.

CRIPPLING LOSS

The crippling loss for three years averaged 17.6 per cent of the hunter bag. However, a crippling loss of 24.7 per cent, determined from field observation and hunter interview during the days on which goose movement was recorded, is thought to more accurately represent the true situation.

MANAGEMENT SUGGESTIONS

Our analysis of factors affecting the harvest of Canada geese in the Flathead Valley suggests certain management practices. Since for two out of three years a direct relation existed between the number of geese killed and the magnitude of the population, an increase in the number of fall birds should normally improve hunting. The hunting population level can be increased in two ways, first by raising more geese in the Flathead Valley each year and second by attracting and holding more migratory geese. We have been investigating the first of these possibilities for three years but it will require several more years of intensive research before we can draw any firm conclusions. At this time, however, it does not appear feasible to either increase the nesting population or raise its productivity sufficiently to appreciably affect the hunting. No doubt more migratory geese could be attracted and held in the valley as has been done at Horicon Marsh and at Horseshoe Lake. The wisdom of such a practice is questionable and even were it attempted, the build-up would be relatively small—limited by the magnitude of the migratory flights.

There is little doubt that hunting pressure on geese in the Flathead Valley will expand greatly in the years ahead. Since the local goose population, even under intensive management, cannot conceivably be increased to meet this demand, other possibilities must be explored.

We have shown a direct relation between goose movement and kill and that movement is so important in determining hunter success that lack of it can completely offset the normal advantage of a high population level. Conversely excessive movement can more than compensate for a low population level. Movement, to some extent, can be manipulated and controlled, therefore it must be considered a major key in managing geese. Where underharvesting is a problem, movement could be induced; and where there is danger of overharvest, it could be inhibited. Movement of geese in the Flathead Valley can be manipulated by regulating water levels, planting grain on the refuge areas to hold geese there, or establishing closed feeding areas outside the refuges to induce movement to protected feeding sites. Experiments are under way to determine the practicality of this type of management. It appears to offer real possibilities for the intensive management so inevitable in the future.

A direct relation between hunting pressure and goose kill has been shown. Most waterfowl regulations have been directed toward controlling the amount or type of hunting pressure, by setting the length of season, the daily shooting hours, and daily and possession bag limits. These are all federal regulations. However, in the Flathead Valley it may eventually become necessary for the State to add more precise restrictive measures on goose hunting in order to preserve the integrity of the local population. Possibilities are the zoning and limiting of hunting pressure, the closure of heavily hunted flight lanes when the kill has become excessive, limitations on week day hunting when relatively few hunters exert a telling pressure, and a limit on the number of geese bagged per hunter per season. If more drastic measures should prove necessary in the future, hunting pressure could be further reduced by shortening the goose season or by establishing a flexible split season that would focus more of the hunting pressure on the migratory geese.

Regulations based only on the annual flyway surveys probably are not specific enough to insure effective and safe harvesting of Montana's resident geese. As additional information is obtained it may prove advantageous to manage this flock in somewhat the same way as is being practiced in Illinois with reference to the Horseshoe Lake flock. To manage the local geese will require annual inventories of breeding success, periodic censuses, and accurate records of the hunter harvest. This information, when combined with the annual flyway data, should enable the National Waterfowl Council, the Fish and Wildlife Service, and the Montana State Fish and Game Department to formulate local restrictions in the waterfowl regulations, pertaining to this and similar population units.

SUMMARY

1. During 1953, 1954, and 1955, data were gathered on Canada goose numbers, goose movement, hunting pressure and goose kill in the Flathead Valley of Montana in order to evaluate the dynamics of hunting pressure.

2. The fall hunting population was composed largely of locally reared geese.

3. For two out of three years a direct relationship existed between the number of geese killed and crippled and the magnitude of the population levels. An inverse relationship existed during one year and this could be explained almost entirely by lack of goose movement in and out of Pablo and Ninepipe Refuges.

4. There was little correlation between goose movement and goose numbers.

5. A direct relationship was found between the number of geese killed and crippled and the number of geese moving. Movement can completely alter the density relationship of goose kill to goose numbers, and this is a significant factor in the management of Canada geese.

6. A direct relation existed between the number of geese killed and crippled and the number of hours spent hunting geese (hunting pressure).

7. When indices were formed by adding the values obtained for hunting pressure and goose movement for 1954 and 1955 and plotting the combined values against the kill for those years it showed an almost perfect straight line relationship.

8. Hunting pressure did not directly affect the daily movement of geese. Biological drives appeared to be more important.

9. During 1954 and 1955, 90 per cent of the recorded goose movement occurred in or out of the refuges during shooting hours.

10. There was no significant relation between daily local movement of geese in and out of the refuges and weather conditions.

11. Weather did affect migratory movements.

12. Skill and experience of the goose hunters to a large extent determined the effectiveness of the hunting pressure.

13. In 1953, 1954, and 1955, a minimum of 365, 645, and 751 geese were bagged by hunters in the Flathead Valley during the respective hunting seasons. The values for both killed and crippled were 485, 764, and 822 respectively. Thus in 1953, 14.6 per cent of the average hunting season population was killed and crippled. In 1954 and 1955 these values were 29.2 and 38.6.

14. Cripple loss averaged 24.7 per cent of the hunter bag.

15. Hunting pressure and goose movement are factors that can be manipulated and controlled, and offer the best possibilities for refining management of Canada geese in the Flathead Valley.

ACKNOWLEDGMENTS

We are especially indebted to Mary Geis for her contributions during 1953. Harold Knapp and Jerry Salinas also helped to make observations during the first year of study. Martin Onishuk, John Morrison, and George Jonkel served well in 1954. Robert Brown and Ralph Stockstad worked during both 1954 and 1955 and their interest and dependable support is particularly appreciated. Robert Gustafson, Frank Wohlschlager, and Dean Biesemeyer assisted during 1955. Grover Elgan, manager of Pablo and Ninepipe Reservoirs frequently gave of his time and service. Finally we wish to acknowledge the expert piloting of Ralph Cooper and the staunch support of the administrative staff of the State Fish and Game Department.

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DISCUSSION

I noticed one parallel you mentioned—competition in hunting. In fisheries, if we had an increased number of fishermen, we would expect the catch per unit per effort to decrease. Now, with more hunters that would mean more movement and a better kill.

DR. CRAIGHEAD: No, we found that daily movement in and out of the refuges had no relation to the hunting pressure. Hunting pressure could be very heavy and the geese would move in spite of a varied array of men and guns. Other days, when there was very little hunting pressure, very few geese would move. There was no relationship there that we could find.

The heaviest pressure around the refuge occurs early in the season. In other words, hunters tend to concentrate there. But, heavy pressure for a period of days or a week will not prevent the geese from moving. Biological drives seem to be far more important.

MR. JOHN GOTTSCHALK [Arlington, Virginia]: This is a simple question. I just wondered whether this drive for movement is a reflection of hunger or fear or some other factor that makes them move?

DR. CRAIGHEAD: That is a tough question. We have been trying to determine just what it is. There appears to be less movement when water levels are low and more food is available. In other words, when they can feed on the refuges. But, there may be other factors involved. Does that answer your question?

MR. GOTTSCHALK: Well, I still don't know what makes them move, but apparently it is just a question that can't be answered very readily at the present time.

DR. CRAIGHEAD: Well, we found very little correlation between daily movement of geese and any other factor we are working with and maybe that is why goose hunting is what it is. The full-time goose hunters study the movements of the birds but it is just about impossible to tell when geese are going to move. We found no correlation of movement either with population numbers or with hunting pressure. But, there did seem to be a correlation between movement and the water levels in the refuges. Low levels made more food available and the birds simply stayed in the refuges and didn't bother to move out to feed. When this happened the movements dropped off.

THE USE OF RETRIEVERS IN BANDING FLIGHTLESS YOUNG MALLARDS[1]

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The purpose of this paper is to describe briefly the use of retrievers in banding flightless young mallards, and to present data on the relative efficiency of retrievers in this type of work. Field work discussed in this paper was carried out in the vicinity of Kindersley, Saskatchewan, from 1953 to 1955.

The use of dogs in waterfowl research apparently dates back to the late 1940's when C. E. Addy and J. H. Stoudt, both of the U. S. Fish and Wildlife Service, used their Labrador retrievers on summer surveys. It was after a demonstration of the capabilities of Stoudt's dog that we began looking for a retriever to help in the banding phase of a Canadian Wildlife Service project originally set up to investigate the waterfowl depredation problem. In 1953, the emphasis was on mallards (*Anas platyrhynchos*), and pintails (*Anas acuta*), the only species in western Canada regularly feeding on unharvested cereal crops. In 1954 and 1955 the project was narrowed still more to concentrate on mallards. The Canadian Wildlife Service has reimbursed owners for the use of their dogs in all three years.

The first dog used was a Labrador-golden retriever cross owned by M. W. Morgan of Kindersley. It has been used each year, being handled in 1953 and 1954 by the author and in 1955 by R. W. Fyfe, summer assistant, Canadian Wildlife Service. In 1954 a Chesapeake Bay retriever, owned and handled by M. H. Lundy, Game Management Agent, U. S. Fish and Wildlife Service, was also used. Another Chesapeake, owned and handled by the author, was used in 1955. Data is, therefore, available on five dog-crews for the three years.

HABITAT AND WATERFOWL CONDITIONS

Kindersley lies in the north central part of the mixed prairie, about 120 miles southwest of Saskatoon. The landscape is gently rolling, trees are scarce and sloughs are surrounded either by cereal crops, summerfallow fields or prairie, the latter composed of a mixture of short and mid grasses. Patches of snowberry (*Symphoricarpos*) and rose (*Rosa*) frequently occur on the uplands around water areas.

In 1953, banding was carried out in a 1,000-square mile block east and south of Kindersley. In July the average number of sloughs per square mile was approximately two. Many of the sloughs were largely

[1] In the absence of the author this paper was read by Mr. W. Arthur Benson.

choked with sedge (*Carex*), spike-rush (*Eleocharis*) or smartweed (*Polygonum*). Their average area was greater than five acres. Transect-type surveys in June and July indicated a density of three mallard broods per square mile—a figure believed to be below the actual density because the survey sample was inadequate for this area of large sloughs and heterogeneous brood distribution.

In 1954 and 1955, most of the banding was carried out in a 400-square-mile block west of Kindersley. This change of locale was necessary because the block worked in 1953 was practically dry in July, 1954. Water conditions continued to deteriorate and there was less than one slough per square mile in July, 1955. However, most of the water areas that remained were large, an average slough being of the order of 50 acres or more. In the area west of Kindersley, only about half of the sloughs had sufficient emergent vegetation to act as good brood cover. There are no data available on brood densities because of a serious clustering problem. An extreme example of this noted in 1954 was the flocking of more than 175 broods to two sloughs in the same half section (320 acres); about half of these were mallards. During the three years in question, practically all of the banding was done during July and August.

TECHNIQUES

This section treats briefly the techniques we have used to catch flightless mallards at Kindersley. A more detailed account of the techniques used by dog-crews there and elsewhere will be found in a manual on waterfowl banding now being prepared by C. E. Addy, U. S. Fish and Wildlife Service. Reference to training of dogs for banding operations will also be found in the manual.

Generally speaking, dogs are most efficient on small numbers of young on small sloughs. As the number of birds, the size and depth of the area, and the density of emergent vegetation increases, drive-trapping becomes the more productive technique. At Kindersley, we used dogs most frequently where we had indications of fewer than 40 mallards on a slough; this applied more to water areas devoid of vegetation because those wholly or partly choked were usually entered with little perception of what was present. We have seldom tried to work areas with dense stands of emergents unless dogs could be used on them.

One of the first points that a dog-crew learns is that young mallards (and pintails) act as breeds apart from other ducks in their escape behavior. Mallards might well be termed "upland waterfowl" because of their tendency to head for dry land at the slightest provocation. It is this trait that makes them particularly vulnerable to capture by dogs. But this same trait makes it impractical to attempt in one operation the banding of all species on an open slough where mallards are present and are the "target" species. When a mallard brood reaches shore, part of it may stop within the first 10 to 20 yards but the remainder is likely to continue for several hundred yards or into the next slough. In 1954, we caught two young mallards being led by a hen apparently from the slough we had just worked about 1,600 yards behind, to the next slough, 350 yards ahead. It is obviously important to get the dog working on a group of mallards within seconds after it leaves the water. Where this is done, all or a high percentage of the birds involved will usually be caught. Where time is lost driving the more reluctant species, (*e.g.* blue-winged teal (*Anas discors*), shovellers (*Spatula clypeata*), baldpate (*Mareca americana*), ashore, the mallards will have dispersed and neither man nor beast is likely to find many of them because the scent left by birds appears to dissipate quickly.

As indicated above, mallards cannot be kept on small sloughs with little or no emergent cover. To start working such an area we usually tried to make an appearance from that side of the slough with the heaviest cover, thus inducing mallards to move into light cover. On larger open areas the crew either waded into the slough in order to drive birds ashore or one member manned a canoe, causing mallards to drift ashore at various points where the rest of the crew tried to catch them. We have usually used one dog with a two-man crew; two dogs would probably be ideal. While working a water area, whoever was nearest the dog when it found a bird, took it. Both crew members carried birds in hand-nets, sacks or shirts, and, when banding, one handled the birds and the other recorded. We have occasionally used three and four men with one dog, but the additional manpower did little to increase the crew's efficiency. Two crews usually worked separately.

When working upland cover near water, one man stationed himself on the shore where he attempted to intercept flushed birds making a break for the slough; the other worked more closely with the dog. The dogs would usually give a bird to the nearest man, a system that allowed the dog to get after the remaining birds faster, reduced chances of injury to a duck, and was easier on both dog and man.

As the density of emergent aquatic vegetation increases, mallards become harder to drive ashore. Also, the species composition of a slough becomes more difficult to determine. In this situation retrievers were used effectively in water only when it was less than belly deep and, preferably, less than six inches. The usual procedure was to zigzag through a slough wholly or partly choked with emergents and then to work the cover around it. The handlers had to work more closely with the dog in such situations, particularly when birds resorted to diving.

The first task given a dog upon arrival at an apparently unoccupied slough is to scout around it. After the dog has circled the area the handler bases his decision for further action on the behavior of the dog, *i.e.*, whether or not the dog's behavior indicates the presence of flightless ducks around the margin of the slough.

We have also used our retrievers singly and together as an added inducement to move mallards in drive-trapping operations. On such drives the personnel of both crews worked together. After drives the dogs were often used to check upland cover for additional birds and to recapture escaped ducks.

RESULTS

From 1953 to 1955, 3,603 flightless young (local) mallards were banded in the Kindersley district. Of these, 1,818 were caught with the help of retrievers, and the remainder have come largely from drive-trapping operations. As might be suspected with the catch being evenly split between the two techniques, one has complemented the other. However, while the dog-crew catch could have been increased significantly had there been no drive-trapping, it is doubtful that the drive-caught figures would have been much higher if no dogs had been used.

Table 1 presents data on the local mallard catch for each year by crews. The figures do not include banded birds that were recaptured, birds too young to band, or birds that escaped before being banded. It should be pointed out that in this table, the heading "Mallard Catch by Dog" does not mean that every bird in this column was picked up and carried by the dog. This is true in most cases but in others, the dog was assisted by the handelr in getting the duck out of dense grass or heavy brush. In other words, the dog came into contact with every duck listed in this column.

The over-all picture shows that an average two-man dog-crew working the equivalent of 12 full days per season (parts of 18 days) made 72 trips into sloughs and caught 349 local mallards. Such a crew worked 6 sloughs in a 10 to 14-hour day and caught 29 local mallards for an average of about 5 mallards per slough. The dogs were credited with 85 per cent of the local mallards banded by the crew; in other words while each crew member caught one mallard, the dog accounted for 11.

TABLE 1. FLIGHTLESS YOUNG MALLARDS CAUGHT BY DOG-CREWS
KINDERSLEY, SASK.—1953-1955

Year	Crew	Days Worked[1] Different	Days Worked[1] Total	Total[2] Areas	Mallard Catch by Dog	Mallard Catch by 2-Men	Mallard Catch by ——	Total	Dog-Injured	Dog-Killed	Other[3] Ducks
1953	2 Men & Labrador	24	22	161	337	109	50	496	12	1	440
1954	2 Men & Labrador	8	6	28	101±	28±	13	142	3	1	116+
1954	2 Men & Chesapeake[4]	15	11	47	181±	29±	41	251	7	18	136+
1954	2-3 Men & 2 Dogs	2	1	2	32	4	3	39	1	4	5+
1955	2 Men & Labrador	19	8	41	301	16	18	335	9	4	80+
1955	2 Men & Chesapeake[4]	24	12	83	393	61	26	480	24	25	196+
TOTAL		92	60	362	1345±	247±	151	1743	56	53	973+
Average/crew/year		18	12	72	269±	49±	30	349	11	11	195+

[1]Mallards were actually caught on all or parts of the days listed in the first of these two columns. The equivalent in full days worked is given in the second column.

[2]Actual sorties into sloughs. Some sloughs were worked two or more times.

[3]Figures in this column are incomplete for 1954 and 1955.

[4]Different Chesapeakes in 1954 and 1955.

CAUGHT INCIDENTALLY ON DRIVES

	Labrador Caught	Labrador Injured	Chesapeake Caught	Chesapeake Injured	Two Dogs Caught	Two Dogs Injured	Total Caught	Total Injured
1954	9	....	30±	....	16±	....	55±	....
1955	7	1	13	1	—	—	20	2
TOTAL	16	1	43	1	16±	....	75±	2

In 1953, 496 (94 per cent) of 525 local mallards were caught by the dog-crew. Practically no drive-trapping was done in an area characterized by small sloughs, many with dense stands of emergent aquatics. Such sloughs, becoming shallow in July and August, were well-suited to be worked by a dog. The mallard catch was below what it could have been because sloughs with only pintails visible were worked as intensively as those containing mallards. This, coupled with the carrying and banding of all species at each water area, cut down the time available for catching mallards.

In 1954, two dog-crews accounted for only 432± (27 per cent) of 1,572 local mallards banded. 55± additional mallards were caught by dogs on drives. In the area worked that year, sloughs were much larger and there were enough of them with good mallard populations and without emergent vegetation that drive-trapping was the more profitable technique. Another important item was the help received from U. S. Fish and Wildlife Service personnel on drives on larger areas. Although dogs were used incidental to drive-trapping, the number of young mallards caught by them was close to maximum for the water areas worked. Up to July 31, pintails were the only other species kept and banded at each slough. After that date mallards were the only duck banded.

In 1955, 815 (54 per cent) of 1,506 local mallards banded were caught by two dog-crews in addition to 20 dog-caught mallards on drives. The area worked was the same as in 1954 but with no outside help we found that some sloughs, fruitful the previous year, could not be drive-trapped successfully by four men. Other sloughs had dried up. The dogs were used often and, with the help of a canoe, it was found that two men and a dog could capture a large percentage of the number that might have resulted if six or more men had been available for a drive. As in the latter part of 1954, mallards were the only species banded; other birds were released as soon as they were caught unless it appeared that they might interfer with the dog again.

We have not been able to detect any differences in the scenting ability or stamina of the three dogs used. Each has had days when he seemed to be exceptionally effective and others, more rarely, when nothing seemed to go right. We do not feel that comparisons of the catch per area or per day or of the dog-caught-to-man-caught ratio for these three retrievers are valid. The number of birds present, the cover, the method of working an area, weather and personnel, more likely influenced the catch than the dog used. The dogs can be compared, however, on the injuries, both fatal and non-fatal, that they caused.

The following remarks refer to individual characteristics of the dogs used in the Kindersley area. A Labrador-golden retriever cross is the only one that has been used for more than one year. In its three seasons, it has worked the equivalent of 36 full days and has actually come into contact with 755 banded local mallards (including those caught on drives). With this dog the crew's average daily catch was 23 in 1953, 24 in 1954, and 42 in 1955. The average catch per area in each year was 3, 5 and 8, respectively. The 1953 figures are not strictly comparable because equal emphasis was put on pintails and the mallard catch was thereby depressed. The reason for the increased catch in 1955 over 1954 is not known; it may have been due to increased experience with the dog in the new area or to higher mallard populations on the areas worked. This dog is the most gentle we have ever used; it has a known kill rate of less than one mallard per hundred actually caught by it. It has shown no tendency toward becoming hard-mouthed and its performance with shot birds during the hunting season has remained at a consistently high level.

An eight-year-old Chesapeake Bay retriever was used in 1954 for the first time. This dog had never been used before on this work. Although blind in one eye, the average catch for its crew was 23 banded mallards per day and five per slough. It was the roughest of the three dogs used but was known to have killed only one bandable mallard of every ten it actually came in contact with.

In 1955 a different Chesapeake Bay retriever was used. This dog was only 15 months old when it caught its first local mallard. With its two-man crew it went on to average 40 banded mallards per day and six per slough. The known kill for this dog was one in 17 or about 6 per cent.

While extremes in numbers caught may be of little value, the following records may be of interest: on July 14, 1955, the Labrador cross was credited with actually catching 49 local mallards from one slough after a relatively unsuccessful drive had netted 23 mallards in the trap. Catches of more than 20 banded local mallards on a single area were made by dog-crews on six other occasions.

Our records show that on 40 occasions crews spent whole days in the field working with dogs. On each of ten such days more than 40 young mallards were banded. On July 20 and 21, 1955, with one crew working both days and the other losing half a day because of car trouble, 231 local mallards were banded.

INJURIES

For any banding technique, a primary consideration is the mortality factor inherent in it. Table 1 shows that the dogs are known to have killed an average of 3.6 per cent of the bandable mallards caught by them. This figure varied with different dogs from less than 1 per cent up to 10 per cent. Non-fatal injuries averaged 4.1 per cent, varying from 3.3 to 6.2 per cent. Of 54 injured ducks that were banded, there have been two direct U. S. recoveries. This indicates that a number of these birds do survive.

The causes of injuries, both fatal and non-fatal, are difficult to determine. It is our impression that more injuries result from the dog's pouncing on birds and digging them out of heavy cover with teeth and feet, than from the dog's carrying birds. When working dense cover we tried to keep up with the dogs and to dig out the birds ourselves after the dog found them.

A more difficult quantity to determine directly is the loss, after release, as a result of undetected injuries inflicted by dogs. With adequate data it should be possible to calculate this indirectly by comparing recovery rates for ducks caught by dog-crews with those caught by drive-trapping. Using Kindersley data it is necessary to make a further distinction between neck-banded mallards and those not so marked (normal), because there is some evidence that rates of recovery may not be the same. (Banding recovery data have been taken from U. S. Fish and Wildlife Service 3-624 flimsy sheets. These have not been checked with recent I.B.M. listings and therefore some of the percentages may be slightly in error.)

Unfortunately the samples are small, but direct returns to date for normal mallards (4½ to 9 weeks old) are 9.1 per cent for drive-

TABLE II. DIRECT RECOVERIES OF LOCAL MALLARDS KINDERSLEY, SASK., 1953-1955.

(Ages: 4½-9 wks.)[1]

	Normal				Neckbanded			
	Drive-Trapping		Dog-Crew		Drive-Trapping		Dog-Crew	
Year	Banded	Recovered	Banded	Recovered	Banded	Recovered	Banded	Recovered
1953	0	0	58	4	10	2	319	33
1954	191	22	194	17	662	54	148	10
1955	73	2[2]	254	16[2]	456	27[2]	310	31[2]
TOTAL	264	24[2]	506	37[2]	1,128	83[2]	777	74[2]
Per cent Return		9.1%[2]		7.3%[2]		7.4%[2]		9.5%[2]

[1]3-4 week old mallards were omitted because while they made up 49% of the *normal* mallards, there were no *neckbanded* birds under 4½ weeks. The return from 3-4 wk. birds is much lower than that from older birds.

[2]Because not all 1955 direct recoveries were in when this paper was prepared, the figures so marked are low and comparisons between 1955 and other years are not valid.

trapped birds, and 7.3 per cent for dog-crew mallards. (As indicated in Table I, the dogs accounted for 85 per cent of the birds banded by the crews.) For neck-banded mallards of the same ages, drive-trapped birds have yielded 7.4 per cent returns to date, compared to 9.5 per cent for dog-crew birds. Chi-square tests showed that neither of these differences is significant. A chi-square test comparing the number of recoveries from dog-crew mallards and drive-caught mallards for neck-banded and normal birds combined, showed no significant difference at the 20 per cent level. The returns from unmarked mallards, 3 to 4 weeks of age, were 4.3 per cent of 233 drive-caught birds and 4.9 per cent of 494 dog-crew mallards. There were no neckbanded birds in this age group.

An analysis of returns by age groups and for individual dogs does not appear feasible at the present time because of inadequate data.

COST

For a two-man dog-crew working the equivalent of 20 full days in a 30-day period and banding an average of 29 local mallards per day, a cost of $1.52 per banded mallard has been calculated. This has been computed as follows:

Subsistence:	30 days x 2 men	@ $10.00 per man day	$600.00
Travel:	30 days x 125 miles per day	@ $ .07 per mile	262.50
Dog:	1 dog for 4 weeks	@ $ 5.00	20.00
	TOTAL		$882.50

Local mallards banded: 20 days x 29 = 580

∴ Cost per local mallard banded $1.52

It is not valid to compare this with the cost of our drive-trapped birds because we usually carried out drives only under ideal conditions. We have never drive-trapped a slough that could not be successfully, though less efficiently, worked with dogs, but we have worked many sloughs with dogs that could not be driven.

OTHER SPECIES

While our records are incomplete in this regard, pintails apparently made up about two-thirds of the other species caught by dog-crews. Baldpate were a poor second followed by coots (*Fulica americana*), shovellers, blue-winged teal, gadwall (*Anas strepera*), green-winged teal (*Anas crecca*), canvasback (*Aythya valisineria*), and lesser scaup (*Aythya affinis*). In the case of pintails, the catch reflects both their abundance and affinity for land. With the other species we are not prepared to say which factor is responsible for the order in which they appear. In 1953, when more accurate data were kept on all species, we estimated that the Labrador retriever caught about 800 ducks of all ages. The average number of ducks banded per day by the dog-crew was 43 (including mallards), and the maximum was 91.

Conclusion

From the data presented above, we conclude that to catch an adequate, well-distributed sample of mallards (and pintails) in the "grassland" habitat of southwestern Saskatchewan and southeastern Alberta, the most efficient and practical technique is the use of retrievers. Correspondence from other workers indicates that this is also true for the surrounding "parkland" habitat of southern Manitoba, Saskatchewan and Alberta. Whether this technique can be extended to other dabbling (puddle) ducks we are not yet prepared to say.

Summary

Data are presented on the results of three years' experience with five dog-crews banding flightless young mallards in the Kindersley, Saskatchewan, district. Habitat and techniques are described. One Labrador-golden retriever cross and two Chesapeake Bay retrievers were used to help catch 1,818 local mallards. The average season's catch for a two-man dog-crew working the equivalent of 12 full days were 349 young mallards. This was well below the potential catch by dog-crews because of drive-trapping. Although the samples are small, a comparison of the direct returns for local mallards caught by dog-crews with those caught in drive-trapping operations indicates no difference in recovery rates.

DISCUSSION

Moderator Everhart: It seems to me there are two or three points here that are worth considering. One is this business of whether to use a pointer or a retriever, and I think you might get a little emotion into that. Another point would be the size of the crews. I was interested in the comment that Mr. Gollop in writing to me made, that the ideal crew would be a one-man, one-dog crew, and in parenthesis, he added, "if you could teach the dog to either band or record." So, I gather he favors more than one man working with a single dog.

Mr. Benson: I might add one point. In all our work, we have come to the conclusion that the dogs are much brighter than the men all around, anyway.

EFFECTS OF TURBIDITY ON FISH AND FISHING

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Fishery workers have known for many years that turbidity caused by erosion silt has a harmful effect on fish life—hence, fishing. Numerous studies have dealt with phases of this problem, but none of recent date have been concerned with a direct measure of how erosion silt affects fish growth and reproduction, basic food production, and fishing success. Our study on ponds and reservoirs in Oklahoma was designed to categorize and measure these influences.

For two years we collected data from farm ponds and large reservoirs, and during the second year we also had the use of a series of small hatchery ponds. The farm ponds—39 in all, with a wide range of natural turbidities—were rotenoned and then restocked (with largemouth bass and bluegills or largemouth bass and redear sunfish) at the start of the study, in 1954. In the hatchery experiments, turbidities were created artificially. On the two large reservoirs—one muddy, one clear—natural, uncontrolled fish populations were studied and public fishing success was sampled.

FARM POND STUDIES

Seines, electro-fishing gear, and rotenone were used to check the fish populations at the end of each of the two growing seasons. The results showed that turbidity has a marked influence on the production of fish. The clear ponds yielded not only a much greater weight of fish but also greater numbers of large fish.

The twelve ponds for which total population estimates were made at the end of the second growing season were separated into the following turbidity classes: (1) clear ponds, with average turbidities of less than 25 p.p.m.; (2) intermediate ponds, with a range of turbidities from 25 to 100 p.p.m.; and (3) muddy ponds, with turbidities in excess of 100 p.p.m. The average total weight of fishes in clear ponds was 161.5 pounds per acre, as compared to 94 pounds per acre in intermediate ponds and only 29.3 pounds in muddy ponds (See Figure 1). Growth was faster and the bluegills and redear sunfish, in particular, reproduced much more abundantly in the clearer water.

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[1] The author was employed by the Oklahoma Game and Fish Department during the period of this study, which was a cooperative project of the Outboard Boating Club of America, the Oklahoma Game and Fish Department, and the Sport Fishing Institute. The Oklahoma Fishery Research Laboratory, the U. S. Corps of Engineers (Tulsa District), Oklahoma A. and M. College, the University of Oklahoma, and the City of Tulsa also provided facilities and valuable assistance from personnel to make this work possible. A more detailed report on this project is available from the Oklahoma Fishery Research Laboratory, Norman, Oklahoma.

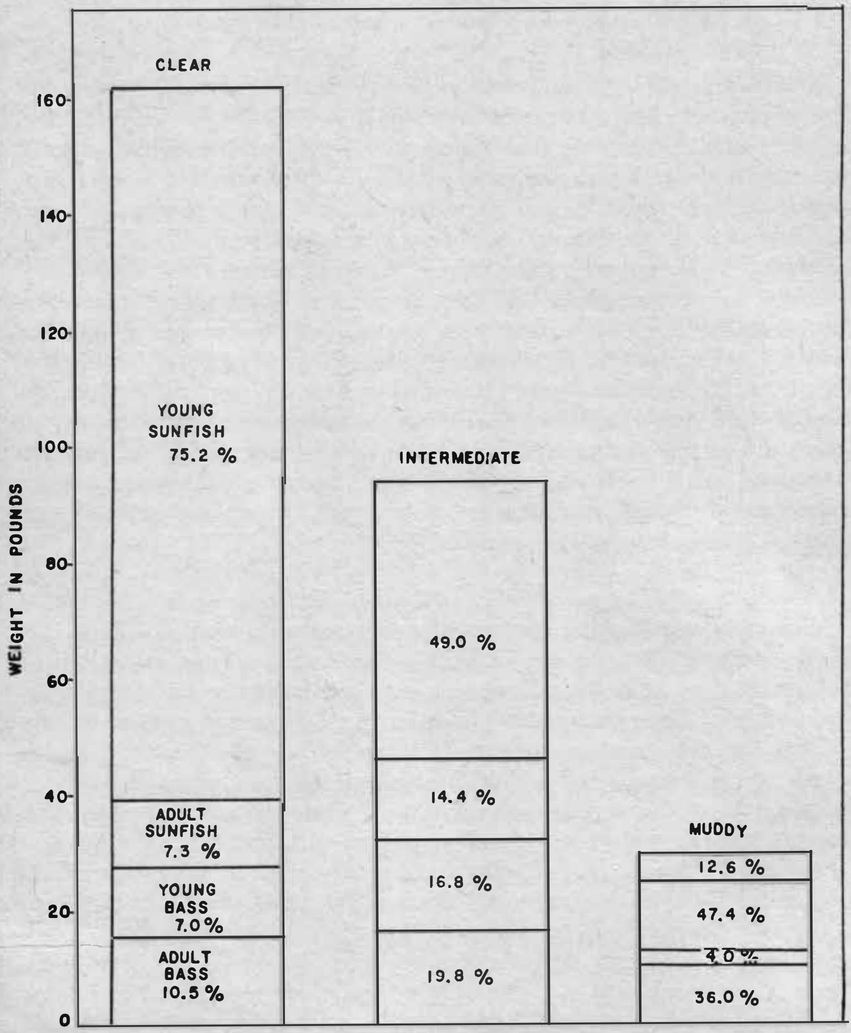


Figure 1. Average estimated total weights and compositions of fish populations in four clear, four intermediate and four muddy ponds at end of second growing season. Fish classed as adults indicate surviving original stock; fish classed as young indicate combined reproduction for both years. Bluegill and Redear sunfih are combined as sunfish; four ponds containing Bluegill, eight Redear sunfish.

Similarly, the muddy ponds did not yield as many bass of desirable length (10 inches or longer) as did intermediate or clear ponds.

Bass in the 6- to 10-inch length range were more abundant in clear than in intermediate ponds, but there was a greater yield of small bass (less than 6 inches) in intermediate ponds, making the total weight of bass of all sizes somewhat greater in the intermediate ponds. Competition from bluegills or redear sunfish seemed to explain these differences, since the weight of sunfish from clear ponds was more than twice as great as from intermediate ponds.

The effect of turbidity on growth rates followed a similar pattern. At the end of the first growing season, bass in the clear ponds had increased their average individual weights 6.4 times; in the intermediate ponds, 4 times; in the muddy ponds, 1.26 times. Corresponding growths in inches were 4.5 in the clear ponds, 3.4 in the intermediate ponds, and 1.5 in the muddy ponds. Our final check at the end of the second growing season further emphasized these differences. Bass in the clear ponds had increased in weight approximately 14 times; in the intermediate ponds, 7.1 times; in the muddy ponds, 2.5 times (See Figure 2). Corresponding average increases in length were 6.9, 5.1, and 2.4 inches, respectively.

The first year's results for bluegills and redear sunfish were con-

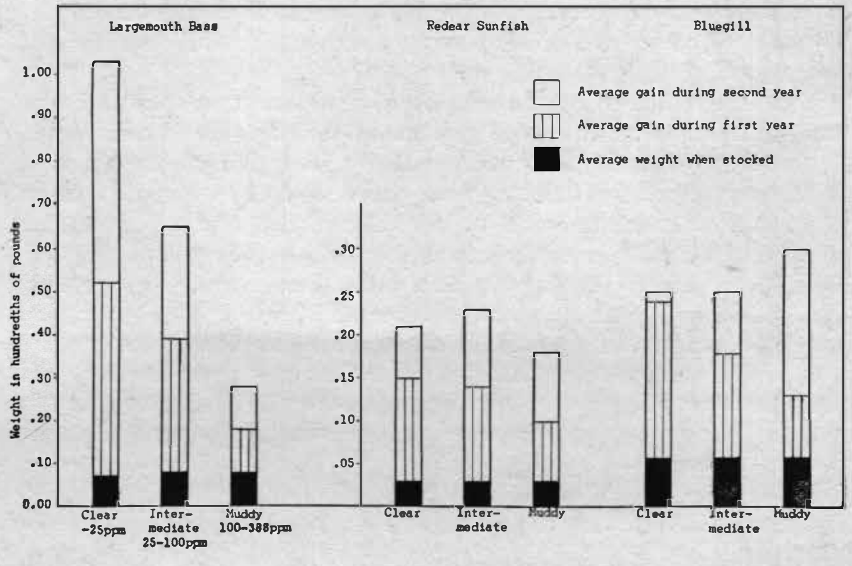


Figure 2. Average weight gains made by individual fish in 12 clear, 12 intermediate, and 9 muddy ponds as indicated by samples obtained at end of each of two growing seasons.

sistent with those for bass, but intraspecific competition and mortality had a marked influence on growth data for sunfish at the end of the second year. Pond No. 29, the most turbid pond (185 p.p.m., average) in which bluegills were stocked, provides a good example. It produced the poorest first-year growth of all bluegill ponds and also had the lowest reproduction rate. The estimated total weight of young (10.9 pounds, both 1954 and 1955 spawn combined) was less than the weight of the surviving adults (17.4 pounds).

As a result, during the second growing season these adult bluegills had less competition than the bluegills in the other ponds. They increased their individual average weight from a ranking of last at the end of the first year to a ranking of second at the end of the second year.

Turbidity also affected reproduction. At the end of the first summer, young-of-the-year bass were found in 7 of 12 clear ponds, 4 of 12 intermediate ponds, and in 0 of 9 muddy ponds. The most turbid pond from which young bass were recovered in 1954 averaged 84 p.p.m.

Redear sunfish indicated more tolerance than bass for turbidity. They spawned successfully in 8 of 9 clear ponds, 9 of 9 intermediate ponds, and 1 of 7 muddy ponds. The highest turbidity from which young redear were recovered averaged 174 p.p.m. Older and larger bluegills spawned successfully in all 9 ponds in which they were stocked, including two ponds having average turbidities of 124 and 185 p.p.m.

Evidence indicated that, during the first season, turbidity and associated conditions had retarded growth and development in some ponds to the extent that the fish were physically incapable of reproduction. In the second year, young bass were produced in 3 of 7 muddy ponds and in all of 11 intermediate ponds. Also in the second year, redear sunfish spawned successfully in two muddy ponds in which they had failed to reproduce during the first year. But in two other muddy ponds there were still no young redear sunfish after the second year, and it is doubtful if they could ever spawn there successfully since they had already attained a length of 6 inches or greater. It is also doubtful that the bass could have spawned in later years in the most turbid ponds since they seemed more limited by turbidity than redear sunfish.

Rates of reproduction also varied according to the degree of turbidity. For redear sunfish, the average production in clear ponds (100.3 pounds per acre) in 1955 was approximately 3 times the production in intermediate ponds (32.5 pounds per acre) and more than 300 times the production in muddy ponds (0.33 pounds per acre). Weight of the young bluegills in clear ponds was approximately 18 times the weight of young bluegills in muddy ponds. These comparisons were based on results from only two clear and two muddy ponds, but the less complete records from other ponds showed the same general proportions.

There was a higher average weight of young bass in the intermediate ponds than in the clear ponds; but, as explained earlier, this was believed to be the result of heavy competition from the companion sunfish in clear ponds.

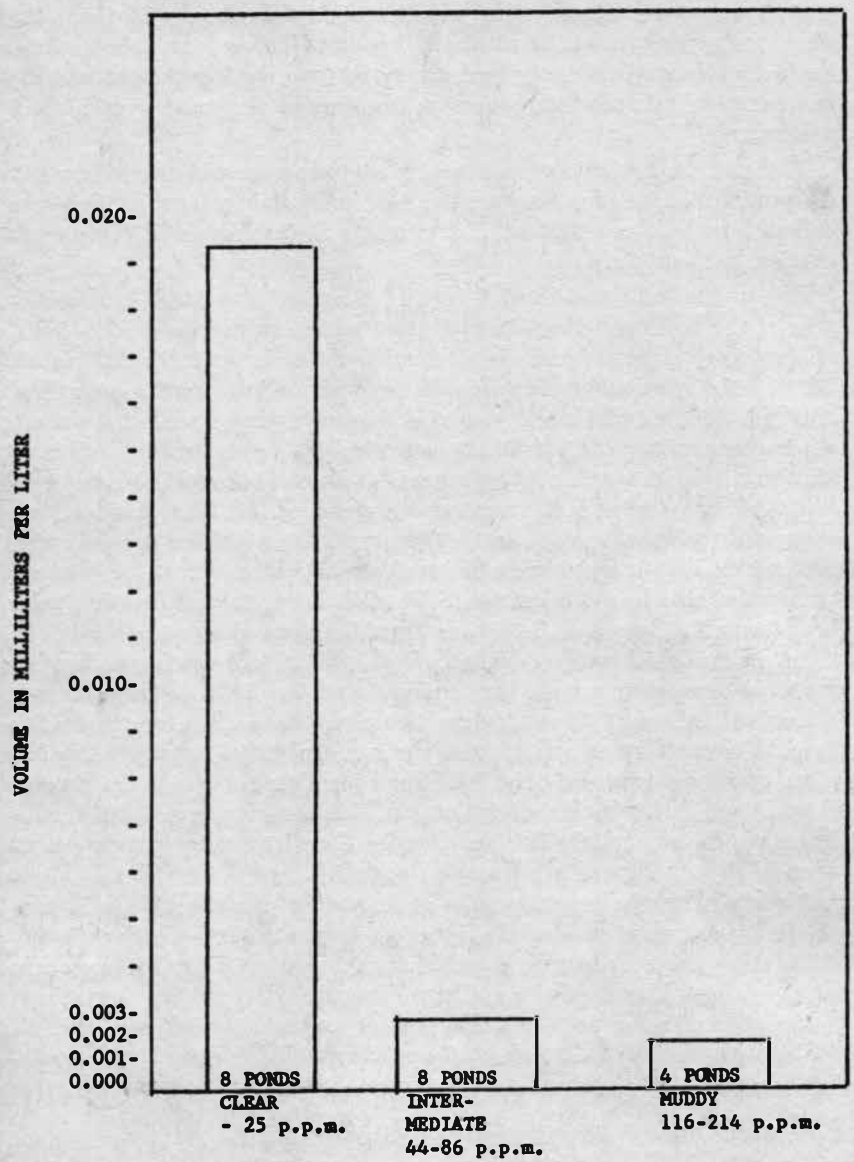
Due to the influence of such factors as age of the ponds and condition of the bottoms, it was not possible to determine the precise level of turbidity above which reproduction became severely restricted. Certain observations could be made, however. Newer ponds with firm, unsilted bottoms produced young at higher average turbidities than older ponds with soft, silt-laden bottoms. The greater fertility common to new ponds was probably an additional factor. Based on average turbidities compiled over the two-year period, the critical level appeared to be between 75 and 100 p.p.m. for all three species, with 100 p.p.m. as the approximate level above which spawning was severely restricted or non-existent. Furthermore, the critical limit for bass seemed to be somewhat lower than for the sunfishes.

In a correlated study (Claffey, 1955), 20 of the farm ponds were sampled once each month for 6 months of the 1954 growing season (April to October) to determine the abundance of microscopic fish food. Volume of net plankton in the surface (0 to 2 feet) waters in clear ponds (average: 0.0192 milliliters per liter) was 8 times greater than in ponds having intermediate turbidities (average: 0.0024 mililiters per liter), and 12.8 times greater than in muddy ponds (average: 0.0015 milliliters per liter) (Figure 3).

Light penetration appears to be an important limiting factor in productivity of turbid waters. Using a spectrophotometer Claffey (1955) found that in water having a turbidity of 25 p.p.m., only 24.9 per cent of the original light of the red wave lengths (the most penetrating) was visible at a depth of 4 inches; at 50 p.p.m., only 6.3 per cent. At turbidities of 150 p.p.m., no light of any visible wave length penetrated through a depth of 3 inches.

HATCHERY POND EXPERIMENTS

Further tests were made at the State Fish Hatchery, Durant, Oklahoma. Use of hatchery pond minimized the effects of such natural, uncontrolled variables as fertility and physiography of the pond



Figur 3. Average volumes of net plankton in surface waters of three categories of farm ponds as determined from monthly samples taken from April to October, 1954.

basins and watersheds and also made possible a more complete return of the fish populations. Turbidities were artificially created in two ways: (1) sodium silicate was mixed with a native clay in six ponds, and (2) adult carp were added to six other ponds. Two untreated ponds (originally 4, but 2 became contaminated with trash fish) remained clear as controls.

Sodium silicate proved effective in sustaining the turbidities. Soil alone settled out quite rapidly, but the use of 1.2 cubic centimeters of the chemical with 10 grams of clay soil per gallon of pond water caused the finely divided soil to remain in suspension for long periods of time. Furthermore, sodium silicate is relatively inert and exhibited no obvious effect on fish, plankton, insects, or other aquatic organisms. Within broad ranges, the turbidities could be controlled. Four ponds were treated with combinations of clay and the chemical; two were treated with the chemical only.

In the ponds receiving carp, their reproduction was eliminated by stocking males only or females only. The carp proved effective, but the turbidities were less precisely controlled than desired since there was little correlation between weights of carp used and degree of turbidity created and because the addition of clay had little influence in the absence of the chemical.

Each of the 14 ponds were stocked with 125 largemouth bass, 100 bluegills, and 50 channel catfish. The bass were young-of-the-year (1.9 inches, average) and both the bluegills (3.1 inches, average) and the channel catfish (3.5 inches, average) were yearlings. The ponds were visited every third week throughout the summer, and additional treatments were given when necesary to maintain the desired degree of turbidity. Eight ponds developed excessive plant growths which twice had to be thinned.

Results from these ponds were generally similar to those from the farm ponds. Clear ponds produced notably faster growths, and greater total weights of both bass and bluegills, but a greater weight of channel catfish was produced in the muddy ponds than in either clear or intermediate ponds.

Average total production (all three species combined) in 3 clear ponds was 137 pounds per acre; in 7 intermediate ponds, 94 pounds per acre; in 4 turbid ponds, 98 pounds per acre. The faster growth by bass and bluegills largely accounted for the greater weight in the clear ponds. The larger total weight in turbid ponds than in intermediate ponds is attributed to the fast growth and high survival of catfish. Growth of catfish was somewhat faster in clear ponds, but this was more than compensated for by their much greater rate of survival and by the greater total weight produced in muddy ponds.

Quite surprisingly, the presence or absence of carp had little influence on the total weight of the companion fishes. Considering the species separately, however, the carp exerted varying influences. Growth of bass and parent bluegills was less in carp ponds than in turbid ponds without carp. Total weight of bass was also less in carp ponds, but the total weight of bluegills was greater due to the abundance of young produced in the carp ponds. Total weight of channel catfish averaged higher in carp ponds than in either clear or turbid ponds without carp. This was due to a much higher survival—75 per cent, as compared to only 35 per cent in clear ponds and to 47 per cent in turbid ponds without carp.

The suggestion that the presence of carp in some manner enhanced the production of catfish is too strong to ignore. The beneficial influence might have been due to the elimination of aquatic weeds by the carp and/or their reduction of aquatic insects known to prey on young catfish. There was also noted a consistently greater production of young bluegills in the carp ponds, and this might be attributed to the same factors.

RESERVOIR STUDIES

The reservoir phase of the project was designed to provide comparative data from two large bodies of water—one muddy, the other clear. Further comparisons were made with other new reservoirs in Oklahoma.

Heyburn, a 1,070-acre Corps of Engineers impoundment on Polecat Creek in Creek County, Oklahoma, was selected as the muddy reservoir. It has been turbid most of the time since its impoundment in 1950, with surface turbidities during the project ranging from 300 p.p.m. in March, 1954, to 51 p.p.m. in August, 1955. Summer averages: 136 p.p.m., in 1954; 126 p.p.m., in 1955. Average depth is 10 feet; maximum, 42 feet. The bottom consists of partially cleared mud flats, and the surrounding terrain is moderately hilly, agriculturally poor, and severely eroded.

Upper Spavinaw, a 3,192-acre water supply reservoir for the City of Tulsa, was selected as the clear reservoir. Average depth is 25 feet; maximum, 92 feet. Flat shore lines and silted, mud bottoms are restricted almost entirely to a small headwater region, and the reservoir has remained clear since its impoundment in 1952.

Results from these reservoirs paralleled those from the farm ponds. All species of fish compared grew faster in the clear reservoir, where gizzard shad, largemouth bass, and bluegills were the predominate species. Catfish, carp, carpsuckers, and white crappies were more common in the muddy reservoir.

Heyburn yielded a preponderance of relatively old bass and a scarcity of young bass, which is unusual for a new reservoir. For example, of 56 bass collected in 1954, 64 per cent were in their fourth year and 32 per cent in their third year. This was representative of all samplings. All evidence points to a small population dominated by slow-growing, older bass and with limited recruitment through natural reproducton. It seems doubtful that the bass population will be able to sustain itself in the face of increasing turbidities.

In contrast, young-of-the-year bass were abundant at Upper Spavinaw both years of the study. To illustrate, the population of fingerling bass in a 10-acre cove rotenoned in1955 was estimated conservatively at 21,780.

White crappies grew more slowly in Heyburn Reservoir than in other Oklahoma reservoirs of similar age and size. The average second-year length was 5.0 inches, more than 3.0 inches less than the next slowest growth in six new impoundments. Also, there was an unusual dominance of older crappies. Judging on numbers alone, the white crappie population would not be considered as overpopulated. But in consideration of the slow growth, it is apparent that their numbers exceed the supply of food and/or other requirements. Thus there is, in effect, overpopulation. It is doubtful that white crappies will ever be important in the catch of Heyburn anglers.

Black crappies, which have less affinity for turbid conditions, are rare in Heyburn. In Upper Spavinaw, however, black crappies far outnumber the white crappies, and collections of both species consisted chiefly of yearlings.

Both channel catfish and flathead catfish are abundant in Heyburn Reservoir. From Upper Spavinaw, only two adult channel catfish and one adult flathead were taken. In the first year of clear reservoirs, the bass, crappies, and other scaled species apparently out-produce the catfish and then limit them by predation on their young. Turbid waters, on the other hand, offer young catfish protection from these predators. Furthermore, catfish can find food in turbid waters more easily than can species which do not have so highly a developed sense of smell. As a result, the bass and crappies lose ground. Even growth of the channel catfish, however, was slower in Heyburn than in less turbid waters. Flathead catfish exhibited the most favorable growth of any Heyburn species studied, reaching an average length of 28.3 inches in their fourth year.

Totally, poundage of fish produced at Heyburn was less than in

Upper Spavinaw—and also less than in other Oklahoma reservoirs. Rotenone sampling in Heyburn yielded 117 pounds per acre in 1955; Upper Spavinaw, 177 pounds. The ratio of forage fish (shad, minnows, and small sunfish) to predaceous species was approximately 1:1 at Heyburn; 13.1 at Upper Spavinaw. In Heyburn, the combined weight of rough fish (carp, bullheads, and suckers—channel and flathead catfish are classed as sport or food fish in Oklahoma) represented 42.4 per cent of the population; at Spavinaw, 7.0 per cent.

Gizzard shad made up more than 70 per cent of the total weight of fish in Upper Spavinaw, less than 10 per cent in Heyburn. Since plankton-eating shad are the principal food of most carnivorous species, their scarcity was a strong limiting factor. This deficiency reflects the marked contrast between plankton production in the clear and turbid reservoirs. In 1954, the volume of net plankton in surface waters averaged 13.5 times greater in Upper Spavinaw than in Heyburn.

Similar differences were noted in the type of fishing engaged in and the fishing success. Heyburn has little natural beauty, necessary to attract vacationing anglers. Most fishing there is done from the bank by local anglers using natural baits and cane poles or trot lines. Fishermen on Upper Spavinaw, which is scenic, use boats and motors and fish mostly for bass using artificial lures.

Creel census data showed that from 3 to 4 times as many fish were caught from Upper Spavinaw for the same unit of effort. Records of the City of Tulsa for September, 1954, through August, 1955, reveal an average catch per fisherman hour of 0.94 legal fish, of which 54.5 per cent were largemouth bass; 30.5 per cent crappies (black and white); and the remainder smallmouth bass, miscellaneous sunfishes and black bullheads. A census of Heyburn during the summer and fall of 1954 showed a catch of 0.25 fish per fisherman hour. The catch consisted of 45 per cent crappies, 35 per cent largemouth bass, 15 per cent channel catfish, 3 per cent bullheads, 1 per cent sunfish, and 1 per cent flathead catfish. These figures do not include trot-line fishing, however. From June through October of 1954, a total of 1,663.5 hours of trot-line fishing were recorded. This represents the total hours when baited lines were in the water. The catch consisted of 195 fish (155 channel catfish, 36 flatheads, and 4 bullheads), representing 0.12 fish per trot-line hour.

The census figures above are not believed to show as much difference as may really exist since the checks on Upper Spavinaw missed several periods when outstanding catches were made. For example, Mr. Sam Jackson, biologist for the City of Tulsa, estimated the bass catch by fishermen using rental boats in the period from mid-August to mid-September of 1953 to have been 14,000 legal-sized bass. His figures did not include bank fishing or private boat fishing. This may have been a peak period, but it is doubtful if 14,000 legal bass have been harvested from Heyburn since its impoundment.

SUMMARY

1. At the end of two growing seasons, the average total weight of fish in clear farm ponds was approximately 1.7 times greater than in ponds of intermediate turbidity and approximately 5.5 times greater than in muddy ponds. Differences were due to faster growths by all species and to greater reproduction in clear ponds, particularly by bluegills and redear sunfish.

2. Of the 3 species used in farm ponds, largemouth bass were most affected by turbidity in both growth and reproduction. Redear sunfish appeared less retarded in growth than did bluegills during the first year, but the two sunfishes appeared equally restricted in both growth and reproduction during the second year.

3. Average volume of net plankton in surface waters of clear ponds during the 1954 growing season was 8 times greater than in ponds having intermediate turbidities; 12.8 times greater than in the most turbid ponds.

4. In hatchery ponds, high turbidities reduced growth and total yield of bass and bluegills but increased channel catfish production. Individual catfish grew faster in clear ponds, but muddy ponds yielded much greater total weights of channel catfish than either clear or intermediate ponds. This was due to a higher rate of survival.

5. The presence of carp caused reduced growth of bass and bluegills but ponds with carp produced greater yields of channel catfish and young bluegills than ponds without carp.

6. Sodium silicate proved effective in sustaining hatchery pond turbidities when introduced in suspension with finely divided clay.

7. Growths of largemouth bass, white crappies, and channel catfish were much slower in turbid Heyburn than in clear Upper Spavinaw reservoir, as well as in all other Oklahoma reservoirs of similar age and size.

8. Growth of flathead catfish was the most favorable of any Heyburn species studied, and it is apparently well adapted to the turbid environment.

9. The number of species, as well as individuals, of all scaled fishes was low in turbid Heyburn reservoir, apparently due to a lack of suc-

cessful reproduction in the turbid waters and also to competition from the better adapted catfishes.

10. Extreme scarcity of forage species, particularly gizzard shad, limited growth and development of bass, crappies, and other carnivorous species at Heyburn.

11. Heyburn largemouth bass and white crappie populations exhibited unusual dominance by older individuals. This seemed to be due to successively smaller year classes as a result of increasing turbidities.

12. In 1954, the average volume of plankton in surface waters was 13.8 times greater in Upper Spavinaw than in Heyburn, and average volume from the 60-foot depth at the clear reservoir was greater than the combined total from surface, 15-foot depth, and 30-foot depth in the muddy reservoir. This contrast was less marked in 1955, possibly due to somewhat lower average turbidities at Heyburn.

13. The clear reservoir attracted more anglers, yielded greater returns per unit of fishing effort, as well as more desirable species, and was immeasurably more appealing in the aesthetic sense.

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DISCUSSION

MODERATOR EVERHART: As far as silting is concerned, up in Maine where I come from, it is no problem in our lakes. We are getting some silting in our streams, and we consider it pollution. We are getting this silting as a result of poor land management and from bulldozing. We have been able to kind of stop the bulldozing. We have a law now that you can't bulldoze more than 500 feet in one mile of stream. It is a very serious thing because the part that the fishery manager wants to save is the part that the logging company wants to bulldoze. That makes quite an interesting situation.

Now, I know there are some fishery people here who can help us, and Dr. Wiebe, would you comment on some of the siltation in some of the larger bodies of water and help the discussion?

DR. ABRAHAM WIEBE [Tennessee Valley Authority]: These are just general observations. We took our reservoirs on tributary streams like Norris, Potalba, Hiwassee and Chatuga. They are relatively deep. Some have a very well protected watershed so there isn't any local erosion although even in Norris, we get some of the silt from Virginia. But still, Norris is not clearer than any of the main stream reservoirs. Rarely will you have in the surface waters, a turbidity as high as 25 parts per million. Of course, you may at the upper end, immediately after a heavy downpour, run up to 100 or 200 or 300 parts per million, but the main part of the reservoir would have a turbidity of 20 per million or not anywhere near 25 parts per million during the summer, whereas most of our main stream reservoirs have a considerable turbidity, generally about 25 parts per million. And we have and we get many more black bass in a reservoir like Norris or Fontana or Hiwassee, and the same thing applies to wall-eyed pike, than we do in the main stream reservoirs.

Of course, we have another feature. Most of our tributary reservoirs are deep enough to have stratification and if you do get some of that silt coming down from Virginia into Tennessee, that is being subdued. It will not show up at the surface of the reservoir, but will duck under to a depth of 35 or 50 feet and go through as a density current, so that we have essentiallly a clear body of water above and below.

Certainly turbidity is a big factor in the type of fishing you are going to have. Mr. Buck, my experience related to fish hatcheries in Iowa and Texas especially was that our highest bass fishing production was generally in the turbid ponds. That is numerically. But, of course, they were invariably small.

DR. H. S. SWINGLE [Auburn, Alabama]: I would say our results are exactly what you have found, Mr. Buck. You have done a better job of measuring it, but quantitatively the results are all the same.

MR. BUCK: For catfish as well?

MR. SWINGLE: Bass, bluegills, and all.

DR. WIEBE: I would like to ask one question. How muddy does the water have to get before fish are actually killed? In parts per million, that is.

MR. BUCK: Dr. Wallen studied that problem several years back at Oklahoma A. & M. College and he subjected various fishes to turbidities far above and beyond whatever might occur in nature. Up to, I can't recall the exact figures, possibly 100,000 parts per million.

DR. WIEBE: I believe he gave 200,000 before they were actually killed. The reason I ask for this additional information, we have had a lot of tragic experiences recently. On one of our major impoundments, in order to keep the dynamos going, we had to go down to the original channel and, of course expose the entire bottom and of course the only way it could be refilled was by rainfall and that would naturally stir up a lot of that silt. People have been trying to tell me that the last fish died and was buried in the silt. And I have been falling back on the Oklahoma experience in defense of our position.

CHAIRMAN KRUMHOLZ: Thank you very much, Mr. Buck, for a very enlightening discussion.

APPRAISAL OF METHODS OF FISH POPULATION STUDY—PART I

FISH GROWTH RATE STUDIES: TECHNIQUES AND ROLE IN SURVEYS AND MANAGEMENT[1]

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A large body of data on the growth rates of the more important fishes has been accumulated in the last few years and a sizable portion of the fisheries research now in progress is adding to our knowledge of fish growth. We are, I believe, at a stage where the techniques and goals of this research need critical review.

The fact that fish growth rates are readily modified and very responsive to environmental factors makes the growth data valuable as indicators of the general welfare of fish populations. Growth studies are among our most valuable tools in fisheries research, but are we using them to the best advantage? Too often, I fear, we make growth studies merely because we know how to make them—because they are an accepted mode of attack.

METHODS

The methods of studying fish growth can be grouped under three headings: direct observation, length frequency analysis, and interpretation of growth rings on scales, bones, and fin rays. Under direct observation are included studies on fish in hatcheries or ponds where age groups can be kept separate, on fish stocked in new habitats where the growth of the original stock can be readily followed, and on tagged fish. In the last case, there is always the question as to whether the tagging may affect the growth rate so that the data are not representative of the population. Length-frequency analysis consists of plotting the numbers of fish according to their lengths and determining the age groups from the peaks of abundance at various lengths. Usually the growth rates of individual fish vary enough so that the size distributions of the age groups overlap too much to permit the use of this method beyond the second or third year of life. The scales, vertebral bones, otoliths, opercular bones, spines, and fin rays of most fish have rings or bands of growth representing alternating periods of fast and slow growth. The interpretation of these bands as annual rings has provided the bulk of our information on fish growth in natural habi-

[1] From the Iowa Cooperative Fisheries Research Unit sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College, with the cooperation of the Fish and Wildlife Service, U. S. D. I.

tats and our discussion will be largely limited to this method of age and growth study.

Since the specific techniques have been summarized in recent years (Lagler, 1952; Rounsefell and Everhart, 1953), we will limit our discussion to a few of the more significant developments and to some of the problems which need further attention.

In the last 15 years there has been an increased use in growth studies of structures other than scales and otoliths (*e.g.* Adams, 1942; Boyko, 1940; Classen, 1944; Cuerrier, 1951; English 1952a; Galtsoff, 1952; Hart, 1950; Hooper, 1949; LeCren, 1947; Lewis, 1949; Menon, 1950; McConnell, 1952; Scidmore and Glass, 1953; Sneed, 1951). Most of these studies have been on species without scales suitable for growth study, but a few have indicated that the bones or finrays are more easily interpreted than are the scales even where scales are available. Generally, however, scales are more easily collected, stored, and examined than are the bones or finrays. Wider use of bones or finrays to verify scale readings and to aid in establishing valid criteria for scale annuli would be desirable. However, it should be remembered that the bands on bones, finrays, and scales are believed to be due to alternations in growth rate of the fish, and conditions which result in establishing a false annual ring on the scales may also cause false rings on the bones and finrays.

Lack of equipment rarely need deter a biologist from occasional routine examination of scales to determine the ages of fish. Scales can be mounted dry, or moistened with water if they are opaque, between two glass slides held together by adhesive tape or rubber bands (Lewis and Carlander, 1949). They can then be examined under the low power of a microscope, with a good hand lens, or projected with an ordinary 35 mm. slide projector. Where large numbers of scales are to be examined, much of the tedious work may be speeded and lightened by more elaborate equipment.

Many of the research units are now examining plastic impressions of the sculptured surface of the scales rather than the scales themselves (Arnold, 1951; Butler and Smith, 1953; Campbell and Witt, 1953; Gathman and Dawson, 1948; Greenbank and O'Donnell, 1950; Hiner, 1952; Smith, 1954). Besides being more easily mounted, handled, and stored, the scale impressions have the advantage of eliminating all marks except those sculptured on the upper surface. Erosion pits on the under surface of the scale which sometimes obscure the scale ridges are thus eliminated. In the use of scale impressions, however, periodic comparisons should be made between the original scales and the impressions to determine whether the edges of the scale are properly recorded on the impression and whether the scale impression has become distorted through "plastic flow" (Smith, 1954).

Microprojectors add a great deal of convenience in the examination and measurement of scales. A satisfactory microprojector can be constructed rather cheaply if suitable optical equipment is available (Joeris, 1949; Pister, 1953). At least one company produces a microprojector especially modified for scale study.

The lengths of fish in previous years can be estimated from measurements of the annual rings on the scale. These back-calculations are simple, but they are time-consuming when large numbers of fish are used. Alignment charts or nomographs to simplify these computations were described at least as far back as 1918 (Huntsman, 1918; Lea, 1919) but have been widely used in this country only in the last 15 years (Carlander and Smith, 1944; Fry, 1943; Hile, 1950; Smith, 1955). Some have eliminated a step by placing the nomograph on the microprojector so that the back-calculated lengths are recorded without scale measurements (Joeris, 1950; Lowry, 1951; Schuck, 1949).

The study of fish growth from bones takes even less equipment than scale study since the bands on most bones are visible with low magnification. Otoliths, spines, and finrays are usually sectioned for examination. While this sectioning can usually be done with a razor blade, the work can be speeded and improved by special, small power saws (English, 1952b; Leonard and Sneed, 1951; Perryman, 1950; Pycha, 1955). The thin sections can then be handled and projected much like scales. It is often helpful to examine the sections with both transmitted and reflected light.

ACCURACY OF SCALE READING

Although there are situations where an annual ring may not be formed each year or where an extra ring may be formed, the formation of one ring a year on scales, bones, etc. can be accepted as the rule, at least in temperate regions (for summary of much of the evidence, see Van Oosten, 1929). Hile (1941) and others have suggested criteria which can be used to verify the fact that the marks are true annuli in any given population. In any detailed life history investigation these criteria should be investigated. Furthermore all supplementary evidence as to the age of the fish such as can be secured from direct observation and length-frequency analysis should be collected to test and verify the scale analysis. The real problem is not usually whether annuli are formed but whether they are correctly interpreted by the biologist.

With very little training, anyone can learn to recognize the annual rings on the scales of most fish. Frequently, however, there may be false annuli or bands which resemble annuli but which do not represent completion of a year's growth. Many species may form a mark resembling an annulus during the first summer's growth. The annuli of old fish are frequently crowded and some of them may be difficult to recognize. The proper interpretation of the marks on fish scales is an art, requiring considerable experience and judgment.

Interpretation may be improved by detailed studies to establish the criteria by which the annuli can be recognized and separated from other growth checks. It is a definite sign of maturity and progress that more critical studies on the use of scales are now being made and published (*e.g.* Alvord, 1954; Cating, 1953; Cooper, 1951; Sprugel, 1954). Undoubtedly there will always be some marks or rings for which interpretation will be questionable. Most of these false annuli are the result of retarded growth of the fish, the same factor causing the true annulus. Most of the identifying features on the scale will, therefore, be the same or very similar for true and false annuli with the distinguishing criteria being largely the completeness of the growth retardation and the relative positions of some of the rings.

Since the interpretation of many of the scale marks must rest on the skilled judgment of the biologist, sources of bias or prejudgment should be eliminated as far as possible. Knowledge of the size of probable age of the fish may influence the decision as to whether a questionable mark is interpreted as an annulus and therefore the biologist in his scale examination should not have such information. Duplicate readings of all scales with at least two or three days intervening may increase the accuracy with which interpretations are made. In one laboratory the scales are read independently by at least two biologists and the results are compared (Felin and Phillips, 1948). The problem of what to do when the two readings give different ages is a difficult one. A third reading may help in solving it. The elimination of those fish on which agreement is not reached, as has been done in some studies, may introduce a serious error since the more difficult scales would largely be from the older age groups which therefore would not be properly represented in the sample. I would suggest that the fish on which scale readings do not agree be assigned to the most likely age group on the basis of all available information and that the numbers of fish so assigned be reported in the paper.

BODY-SCALE RELATIONSHIP

Back-calculation of fish lengths from measurements of the growth bands on scales, bones or finrays requires a knowledge of the relationship between the growth of the fish length and the structure used in studying growth. Usually it has been assumed that the body growth is directly proportional to the growth of the scale. Wherever the relationship has been investigated, however, it is found that some form of correction is needed because the growth of the two are not directly proportional (for recent summaries see Lagler, 1952; Rounsefell and Everhart, 1953; Schuck, 1949). Probably in every population the true relationship is a curvilinear one. The relationship between scales and body length can hardly be the same when the scales first appear as when scale coverage of the body is completed. Large samples, representing all size groups, are needed to adequately describe the curvilinear relationship for any population. Therefore, except in special studies, it is probably best to assume a rectilinear body-scale relationship. That portion of the growth from the time of first annulus to death, which is the important portion for the usual back-calculations, appears to be nearly rectilinear in most populations which have been studied. More errors may result from attempting to describe curvilinear regressions from inadequate samples than from the assumption of rectilinearity.

The usual method of correcting scale measurements by adjusting to "normal" scale size involves the estimation of scale size from the body-scale regression when the scale-body regression would be more accurate (Whitney and Carlander, 1956). An alternative method of adjusting the computed lengths instead of the scale measurements does not involve the inconsistency inherent in the other method and gives identical results if a rectilinear regression is used.

Mottley (1942) recommended the use of scale measurements to compare growth directly without back calculations. While this method may save considerable effort where the body-scale relationship of a population is well known, larger samples are needed to get the same degree of accuracy as may be secured by back calculation (Whitney and Carlander, 1956) and care must be taken to see that the body-scale relationship has not changed during the investigation (Smith, 1955).

TREATMENT OF DATA

Statistical comparison of the growth data of fish from different populations is complicated because the growth may very in so many different ways. Slow growth early in life may be compensated for by rapid growth in later years. In many situations a simple practical comparison of growth in different lakes can be made by comparing the lengths of time it takes the average fish to reach some selected "catchable'' size, or by comparing the average size of the fish at the end of the second, third, or fourth year of life.

Bertalanffy (1938), Hile (1943) and Walford (1946) described methods of comparing the growth of fish in different populations, but few applications of these methods have been made, probably at least partly because they appear to be quite complicated and because it is difficult to interpret the results in practical terms. Another difficulty is that each of these methods assumes that the growth will follow a particular mathematical relationship and this assumption may not always be met.

Most biologists appear to be satisfied to compare in a direct fashion the average growth derived for a population with averages from other populations without testing the hypothesis that the observed differences may be due to chance. Where the differences are large there may be no need for statistical tests, but we need many more studies of the variability of growth which may occur in populations.

In determining changes in growth in a population or the effects of environmental factors upon growth, annual increments (the differences between calculated lengths at the beginning of two successive years) are usually more informative than are the calculated lengths themselves. The increments can be related to the various calendar years for direct comparison with the changed conditions (see Hile, 1941). Analysis of variance can be used in testing the significance of differences in increments, but has been little used as yet (English, 1952a; Hennemuth, 1955).

Frequently average annual increments have been incorrectly computed. The average computed length at the end of the first year has been subtracted from the average computed length at the end of the second year, etc. However, some of the fish which are used to compute the average length at the end of the second year did not live long enough to be used to compute the average length at the end of the third year and frequently these two-year old fish may have grown at a different rate than those that completed the third year of life. Negative average increments have been reported even though each fish in the population showed some growth each year. Increments should be computed for the individual fish or for age-groups and then averaged, to secure the proper annual increments.

In talking about growth, we are often rather ambiguous about the type of data we are using. Most papers use the average lengths at various ages, which Rounsefell and Everhart (1953, p. 313) call the absolute growth curve. The term ''growth rate'' should be limited to the ''rate of change in size with time.'' Annual increments are one measure of growth rate. Growth rate may also be represented by the slope of the growth curve (Carlander, Lewis, Ruhr, and Cleary, 1953, p. 96).

SAMPLING

The most difficult technical problem in growth studies is probably sampling—*i.e.* the collection of a sample of fish which may be considered representative of the population. It is almost impossible to collect a random sample of a fish population. A random sample is one in which each fish in the population has an equal chance of being collected. Most methods of collecting fish are quite selective as to the size of the fish and probably none is free of some size selectivity. The ecological distribution of fish changes as they grow, and thus their probability of capture in various environments differs with their age and size. A method which selects middle sized fish will tend to catch only the faster growing among the young fish and the slower growing among the old fish.

In many waters there may be more less independent populations, each with its characteristic growth curve, in different areas or habitats. Frequently the samples may come from these separate populations without being recognized as such.

Probably the best we can do at present is to sample as widely as we can and then continually be critical of our sampling. We need to recognize and delineate what portion of the population we are sampling, or what selectivity is taking place, and to apply our conclusions only to the delineated population. Often we must accept a standard system of sampling and hope that comparable portions are taken from the populations being studied.

The size of sample needed depends upon the type of information we need and upon the amount of error which we will accept. Most statistical texts give methods by which the size of sample required can be estimated. A review of some of the published data on fish growth indicates that at the 95 per cent confidence level over 550 specimens would be needed to estimate the mean length at a specified age, within 1 per cent (Table 1). With 30 fish in the sample, the estimate would probably be within 5 per cent. These computations assume that the sample is representative of the population. Increasing the sample size will do little to improve the estimate if the sample is selective or biased.

ROLE IN SURVEYS AND MANAGEMENT

It is probably unnecessary to discuss the place of growth studies in fisheries research or the contributions which they have made to our understanding of fish populations. It might be helpful, however, to

TABLE 1. NUMBER OF SPECIMENS NEEDED SO THAT THE SAMPLE MEAN WILL BE WITHIN 1, 2, OR 5 PERCENT OF THE TRUE MEAN, WITH 95 PERCENT CONFIDENCE IN 19 OUT OF 20 CASES[1]

Species and citation	Number of estimates	1% Median	1% Range	2% Median	2% Range	5% Median	5% Range
At capture							
Salvelinus fontinalis							
Hatchery (Smith, 1955)	11[2]	685	241-1615	183	66-416	35	15-73
Planted (Smith, 1955)	10[2]	430	210-1336	118	56-336	25	12-66
Native (Smith, 1955)	7[3]	682	323-1209	177	86-305	32	17-54
Weekly collection (Cooper, 1953)	8[4]	1027	533-1786	264	139-453	47	27-77
Season's collection (Cooper, 1953)	6	695	553-2481	186	149-491	37	30-111
Salmo gairdneri (Holton, 1953)	1	920		239		44	
Salmo clarki (Brunson, et al. 1952)	2	869	535-1204	218	137-299	39	26-51
Esox lucius (Hooper, 1951)	3	283	180-912	84	48-233	18	11-43
Catostomus commersoni (Smith, 1952)	7	276	126-481	102	35-124	16	8-23
Micropterus dolomieu (Webster, 1954)	8	233	111-567	66	34-152	16	9-30
Pomoxis annularis (Marcy, 1954)	7	1213	142-2021	306	39-504	53	9-83
Lepomis macrochirus (Ball and Tanner, 1951)	8	391	221-1763	101	59-443	20	12-75
Lepomis gibbosus (Ball and Tanner, 1951)	5	770	425-1030	200	110-271	37	22-51
Lepomis gibbosus (Hooper, 1951)	3	692	139-1165	193	38-299	37	9-57
Perca flavesens (Hooper, 1951)	1	464		133		28	
Perca flavesens (Ball and Tanner, 1951)	4	744	602-935	192	154-212	35	30-44
Schilbeodes sp. (Hooper, 1951)	3	663	318-823	181	87-226	36	18-45
Nocomis spp. (Lachner, 1952)	8[5]	713	301-2915	183	81-270	34	17-123
Etheostoma flabellaris (Fahy, 1954)	6	206	138-320	57	38-27	13	10-19
Calculated lengths							
Micropterus salmoides (Lewis, 1950)	10	1374	607-3384	352	158-854	62	30-145
Stizostedion vitreum (Carlander, 1943)	10	149	93-544	43	29-140	11	8-26
Morone chrysops (Lewis, 1950)	5	283	113-1077	78	34-277	18	9-47
Morone interrupta (Lewis and Carlander, 1948)	9	213	90-491	57	27-132	13	8-28
Chaenobryttus coronarius (Lewis and English, 1949)	6	848	537-1947	199	145-494	39	25-86
Combined	146	546	90-3384	152	27-854	28	8-145

[1]Estimated by the method of Harris, Horvitz and Mood 1948, p. 396-397.
[2]Only ⅓ of samples used.
[3]Only ½ of samples used.
[4]Only ⅛ of samples used.
[5]Only ¼ of samples used.

think about their place in routine surveys and fisheries management. Actually, of course, surveys and management are not separate from research, and no hard line can be drawn between them; but for administrative purposes it is often convenient to make at least a partial distinction.

Most routine lake and stream surveys, which have as their goal a general inventory and classification of the waters, now include the collection of fish scales or other growth data. The sampling is usually done according to a "standard" technique in the hope that the samples will be comparable even if they are not representative. The samples of necessity are usually small and for any given body of water usually represent only one small portion of the season. Often a sample collected in August must be compared with another collected in June. The conclusions drawn from these samples must therefore always be somewhat tentative and only large deviations from normal or average growth should be considered significant. Back calculations of growth from these samples probably rarely justify the time expended, since the larger deviations in growth will show up in the lengths at capture.

These survey data often serve a valuable function in providing a mass of data which may be used to represent the average or "standard" growth for the region. Care should be taken in such use to avoid too many "problem" waters. Occasionally the data may also be of research value, as in exploring the effect of various environmental factors on growth (*e.g.* Eddy and Carlander, 1940; Hall, Jenkins, and Finnell, 1954). With reference to management on the individual lakes, the survey data may indicate situations where growth is abnormally slow or fast, and they may also reveal the presence of dominant year classes which will affect the fishing success. Where the surveys can be repeated annually, on an inventory basis, major shifts in the fish populations may be detected. It is probably desirable to collect measurements and scales from as many fish as the field conditions permit even though a small sample is examined in the laboratory. The additional data may be of great value if the body of water ever becomes a subject for special investigation.

Growth data may be important in diagnosing what is wrong with fishing and in prescribing management. Overfishing and underfishing may both result in an abundance of small fish (Bennett, 1945). Growth in the overfished water will be rapid; that in the overpopulated water, slow. Great differences in the abundance of year classes suggest the need for continuing change of fishing methods to increase the harvest on the more abundant fishes.

Although growth rates are modified by many factors, most of these factors are more or less regional in their action so that it usually is fairly safe to assume that very slow growth in a body of water compared to that in neighboring waters is due to overpopulation. Management practices which reduce the population density are then usually indicated.

Much fishery management is still in the experimental stage and therefore it is desirable to follow each application of a management practice with an evaluation study to determine the effectiveness of the management. Growth data may be important indices in such evaluation.

The management of commercial fisheries in an attempt to secure optimum yields rests so firmly upon growth studies and determination of year class abundance that we hardly need discuss their importance here.

CONTEMPLATION

The greatest need in fish growth studies at the present time is more planning of the investigations and more critical analysis of the results. We need to ask, more often, "Why are we doing this particular growth study? What information do we need to get from the growth study?"

I am not one to particularly decry the accumulation of data for the sake of science (Carlander, 1953), but fishery biology would be advancing more rapidly if more of our studies were designed to answer specific questions rather than just contribute to general knowledge. General knowledge of the growth of many species of freshwater fishes has accumulated to a degree that the law of diminishing returns must be seriously considered before embarking upon further general growth studies.

Many of the sampling problems could be simplified if more time were spent, before collection, in determining what questions the growth study is to answer. Then the sampling can be designed to more efficiently answer these specific questions and the sizes of the samples can be selected to give the desired degree of confidence in the results.

More thought is needed not only before the investigation is started but also after the data are in. The results must be critically analyzed, inadequacies in sampling should be recorded, and improvements for future studies suggested. The data should be concisely summarized and the answers and conclusions presented to all who may have use for them. Too many man-years of research are filed away on the shelves of many organizations. How much of this work could just as well never have been done?

This analysis of the data should not be done mechanically (the computations, of course, should be), but contemplatively and inquisitively. Often the results which do not come out as expected may be the ones containing important clues to the desired answers or relationships.

Most of us are in fishery conservation because we enjoy the outdoors and enjoy studying the fish and the fishing. We are apt to be somewhat derisive of the armchair biologist and of the chair-bound administrator. But, the armchair and time to sit in it and mull over fishery problems are among the most essential needs for progress in fish growth research and in fish conservation.

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APPRAISAL OF METHODS OF FISH POPULATION STUDY—PART II

CREEL CENSUSES

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In this day and age, everyone in every field of human activity becomes involved at some time in taking a census. It may be the world's human population; it may be waterfowl; it may be mammals or it may be fish. Everyone in his particular field of endeavor wants to know the population of animals he deals with in a given area or in the whole state or province. Once an enumeration of a wildlife or a fish population is completed, there almost inevitably follows the census of kill or catch. We all agree that the information gained from a census has been most helpful to biologists and administrators in dealing with management and administration problems, and much useful knowledge has been obtained on the many kinds of wildlife that have been studied. Much has been accomplished in setting up regulations and management programs in line with biological facts and information obtained through censuses.

Creel census, as the term implies, deals with the collection and analysis of records on game fish caught by angling. It is generally accepted that the collection of data on anglers' catches started in the twenties. The apparent value of such records was soon recognized, and intensive creel census programs began in the early thirties in the Provinces of British Columbia and Alberta, and in the States of Michigan, Connecticut, Pennsylvania, Vermont and New York. The collection of creel census data was rapidly intensified owing to the availability of workers during the thirties, then dropped to a low level during the war period. Since the end of the second world war, creel census projects have again been expanded, and the activities of creel census workers have been accelerated in the United States and Canada. Today, in every state of the union and in most provinces of Canada the collection of angling data is carried out in one form or another.

From information obtained by a rapid review of papers dealing with creel census, and from personal experience in dealing with activities in this regard in the National Parks of Canada, I would summarize the purposes of collecting creel census data as follows:

(1) To determine total yield in terms of numbers or pounds of game fish caught.

(2) To survey angling success in terms of fish caught per fisherman and per hour.

(3) To determine angling pressure in a body of water, or in a watershed.
(4) To determine the monetary value of angling resources in a body of water or in a watershed.
(5) To determine angling activities within a week, a month or a whole angling season; to compare catch returns from anglers fishing from shore and from boats; and to compare the effectiveness of different types of lures.
(6) To evaluate experimental management techniques.
(7) To contribute to the theory of fisheries biology.

In all instances the ultimate purpose of a creel census program is to gather information which will assist in formulating the best management policies and techniques to provide more successful angling.

Several methods are being used for collecting information from anglers. Printed forms are distributed to anglers entering an area, or placed in boxes where they may be picked up and filled in by anglers themselves on a voluntary basis. In the National Parks of Canada more than 100 boxes were provided for this purpose. They were placed at each lake or stream or at the entrance to a trail leading to one or several lakes. At the end of a season when all cards secured were sorted by lake or stream, half a dozen waters might come up with a much larger number of reports than others. This did not happen because more anglers visited these areas or because anglers were more cooperative in one area than in another, but because a park warden or a caretaker was assigned to see that most anglers completed cards in the area concerned. In many cases the Park employees examined the catches and filled in the cards themselves. Data collected under such conditions were of some use. They were especially valuable to us because a large proportion of fish caught were measured and the data recorded on cards.

The collection and analysis of cards filled in voluntarily by anglers was continued on the assumption that each year the same proportion of visiting anglers would carefully report their successes as well as their failures in catching fish. This assumption was difficult to confirm. Promotional efforts resulted in increasing the number of cards returned, especially of those reporting nil catches. In 1947, a total of nearly 6000 angling efforts reporting the catch of nearly 29,000 fish was recorded. In 1953, the number of efforts reached 20,000, with a reported catch of slightly more than 51,000 fish. Official records indicate a catch of nearly five fish per angling effort during 1947 and 2.5 fish during 1953. These records are misleading because prior to 1950.

efforts recording the catch of two or three species of fish in a body of water were assigned to each of the two or three species in order to calculate indexes of fish-per-hour and fish-per-angling-effort for each species. Therefore, for many lakes and for the most heavily fished, the total number of efforts was artificially increased two and three times. An average reported catch of eight fish per day in 1947 would have been close to the true records. It would therefore seem that angling in the National Parks has deteriorated from eight fish per angler to 2.5 fish during the period 1947 to 1953. Actually this conclusion is wrong on account of the recording of unsuccessful efforts which resulted from the promotional propaganda since 1950. Because of the increasing proportion of beginners among anglers, the indexes describing angling quality and game fish availability are also misleading.

The compulsory recording of catches was established in certain areas for a given species of fish. A mandatory creel census program is feasible only when adequate enforcement is possible. The most successful example on record was achieved in California with respect to marine sport fisheries and catches made from boats. The regulations governing fishing in Canada's National Parks stipulate that all persons angling in the famous Maligne system in Jasper Park must report their catches when leaving the district. Records obtained from these waters are considered to be nearly complete. The use of these records for management is of doubtful value because fluctuations in catches were shown to be affected by economic and other external factors to a greater extent than by any possible changes in the fish population itself.

Another method of securing catch records is to request anglers to report the previous year's angling successes when renewing their application for a fishing license. Some states and provinces mail questionnaires to a certain percentage of licensed anglers and the reports are analyzed. Through this method, the Game Commission of the Province of British Columbia was able to evaluate a total catch of more than seven million fish during 1955, at the rate of 0.61 fish per hour, and with an expenditure of $15.3 million by freshwater anglers and $4.5 million by salt-water anglers.

There is no doubt that a hundred per cent coverage of anglers and of catches is most desirable. Since such an achievement is practically impossible in most areas, random sampling by census workers has been developed in recent years. Refined methods of sampling have been designed by the U.S. Fish and Wildlife Service. An illustration of such sampling and of the subsequent statistical treatment of samples to obtain information on total catches is contained in a recent publication of the U.S. Fish and Wildlife Service on the cutthroat trout in Yellowstone National Park.

RESULTS FROM CREEL CENSUS TECHNIQUES

During the past few years, many scientific papers and articles have been published on one phase or another of creel census and on results and information obtained.

An interesting census report dealing with angling activities was published in the *Colorado Conservationist.* It stated that out-of-state visitors accounted for 21 per cent of the licenses sold in the State of Colorado and that these visitors removed less than seven per cent of the total catch of trout in the state.

Yield by acre has been determined through creel census data. Wide variations in the poundage of fish caught per acre in lakes and streams are recorded. Figures as high as 215 pounds of trout per acre have been obtained. The best records we have in the National Parks of Canada come from Beaver Lake in Jasper National Park where 13.7 pounds of eastern brook trout per acre per year was recorded over the period 1933-47. Like most champions the lake collapsed in 1954 with the population of trout wiped out, presumably because of winter stagnation during the preceding winter season.

Creel census programs have proved useful for evaluating the results of such management practices as: the planting of fish of various sizes, or, the removal of undesirable fish species by netting, trapping or poisoning. Fry's 1950 mimeographed paper presents an excellent review of papers illustrating the use of a creel census program. Many recent papers might be mentioned which elaborate this point. There is one from South Dakota, for example, in which is described the enumerating of catches from a stream planted with equal numbers of marked legal-size rainbow, brown and eastern brook trout. The analysis of creel returns showed that brook trout contributed more to the angler's catch than rainbow trout, which in turn were more frequently taken than were the browns. At the end of the season, only 10 per cent of the eastern brook trout planted were recovered in a stream; rainbow trout came second with 32 per cent, and brown trout first with 50 per cent. Such a well-designed experiment resulted in obvious conclusions. In Pennsylvania, a similar planting in a lake with equal numbers of eastern brook, rainbow and brown trout resulted in a catch of 38 per cent of the brook trout, 48 per cent of the rainbow trout, and 35 per cent of the brown trout planted.

In the National Parks of Canada, several examples could be mentioned where creel census records have been most valuable in following up angling activities and in planning and carrying out the management of game fish in park waters. In Prince Albert National Park for example, an intensified collection of creel census data revealed the extent of angling activities applied to certain waters, particularly for pike. The analysis of data collected during the past few years has shown that more than 25 tons of pike have been caught annually during the past five years. There are no indications that the population of pike is deteriorating as a result of such heavy angling pressure. For pike, the daily catch is limited to five per day per person, and there is no minimum size limit. No change in the regulations is contemplated.

The creel census program which started in the Mountain Parks in 1940 has been quite fruitful, mainly in what I may call sub-products. In certain parks, the promotion of the creel census program in the late forties coincided with the planting of hatchery raised trout with one or more fins removed prior to distribution. Until that time, it had never been fully realized that natural reproduction was absent or unsuccessful in many of the Mountain lakes, and that annual routine plantings were essential for the maintenance of angling opportunities. Anglers were requested to report on cards the number of marked fish in their catch and to identify which fin or fins had been clipped. During the years which followed the stocking of marked fish, the number of cards reporting such fish increased gradually as more anglers paid attention to the markings, and reported the occurrence of marked fish in their catch. However, in no instance did the creel census cards indicate that 100 per cent of the fish caught in a lake originated from the hatcheries, even when tests made with gill-nets failed to catch even one unmarked fish of a given year-class. Creel census reports had to be supplemented by sampling with gill-nets before definite conclusions could be reached. We now feel that several years of effort could have been saved and proper actions taken earlier if field officers had relied on gill-nets instead of on voluntary creel returns to secure the information required. In spite of numerous posters scattered throughout the park, few anglers could identify the right from the left side of a fish or identify the fins properly. The information supplied on cards about the lengths of the fish caught was of little value in estimating the growth of trout following their planting in lakes, because of inaccurate measurements even though the creel census card is marked in inches.

CONCLUSION

There is no doubt that many organizations are at present questioning the value of creel census programs, especially those based on voluntary returns, and are searching for new approaches to the problem of assessing anglers' catches. In fact, the topic of creel census appears on the program of two other meetings which will be held within the next few months: a symposium has been called for March 19, at the Iowa State College, to discuss sampling problems in creel censuses, and the same topic will be discussed at the meeting of the Northeastern Section of the American Fisheries Society scheduled to meet next May in Pittsburgh, Pennsylvania. There are signs that many organizations are losing their enthusiasm for creel census projects and are becoming more critical than in the past of creel census methods. However, there are hopes for better methods of sampling angling activities with statisticians entering actively into the field of fisheries.

Those who have been concerned with the collection of creel census data in one form or another find it difficult to give up projects which they have promoted year after year over a long period of time. You may recall Dr. Solman's paper presented at the Sixteenth North American Wildlife Conference, 1951, where he spoke enthusiastically about creel census programs in the National Parks. My colleague and I now feel that the creel census program in the National Parks of Canada has fulfilled its purpose in most areas and that, even with active promotion, very little may be gained by continuing this program. The policy with respect to the creel census in the National Parks of Canada has recently been revised and the collection of such data will be reduced considerably. In future, creel censuses will be carried out only where and when required for a specific project. Time, efforts and funds which would have previously been devoted to the collection, analysis and publication of general creel census records will now be directed to research projects and management practices and, when required, to the collection of adequate creel census data.

I do not wish to leave you with the impression that the creel census program as carried out in the National Parks of Canada since 1940 has been of no value. On the contrary, it has been useful in providing the best possible opportunity for the establishment of contacts with visiting anglers. Park wardens, hatchery personnel and biologists were able to feel the anglers' pulse and learn the anglers' language and at the same time broadcast information on biological features of game fish, on conservation and management of game fishery. I am proud to say that we have in the National Parks full cooperation and full sympathy from residents and visiting anglers, thanks to information distributed in the course of creel census operations.

Through the voluntary return of creel census cards, it has been possible to classify park waters according to fishing intensity and to reach a decision as to where research and management programs should be directed. The most heavily fished waters were then considered first in planning field operations.

Where officers have been available for obtaining a fairly complete coverage on angling activities and catches, we now have creel census figures which are valuable in establishing the management policy for the waters concerned. In most cases, creel census data have revealed that the increase in angling pressure which fell upon many lakes during the past four or five years has not reached a point where over-exploitation is to be feared and where daily catch of fish should be restricted below the present limits.

However, I have taken the pessimistic position with regard to creel census techniques and the value of the mass of data recorded and accumulated in every one's files. In so doing, I hope to have stimulated my colleagues in this field so that they will favor us by giving their views during the discussion period.

APPRAISAL OF METHODS OF FISH POPULATION STUDY—PART III

THE MEASUREMENT OF FISH POPULATION SIZE

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Fishery workers are well aware of the great value of quantitative and qualitative information on fish populations. Measurements of population size in terms of numbers of individuals are fundamental to growth in understanding of the dynamics of natural production. Data from such measurements are also basic to directed fishery management. Certainly knowledge of what is present must underly policies determining rational use.

Perhaps greatest significance of information on fish population size is in the base that it affords for determining the relationship between standing crop and yield—especially since the recognized aim of fishery management is the achievement of optimal sustained yield. A most pressing question facing fishery workers is "how many fish of catchable size must I try to maintain in a population in order to have 'satisfactory' fishing?" How else can he answer this question than by the study of population accompanied by that of yield. The ability to determine numbers of fish has also afforded the opportunity of measuring directly the effects of management efforts such as liberalization or intensification of regulations, and environmental improvement (*e.g.,* stocking, fish removal, installation of shelters, etc.).

In this paper we review certain of the known procedures for the enumeration of fishes, particularly in inland waters. The procedures considered are of two kinds—direct (actual counts) and indirect (estimations). Techniques of approximating relative abundance from catch-effort data are not included.

By certain direct means of enumeration it has been possible to obtain reliable actual counts of standing crops of fish. In best form, such counts are those made in draining bodies of water and recovering the contained individuals. Weir counts on migratory kinds have also constituted an accurate means of mensuration. Variously less adequate than the foregoing have been attempts to pick up for count as indicative of standing crop all members of intentionally, accidentally, or naturally induced mass mortalities. In complete-kill experiments with rotenone, often involving the release of known numbers of recognizable (tagged or marked) specimens, recoveries have ranged from about one-fifth to nearly all fish present; (*e.g.,* for total range: Fredin, 1950; Krumholz, 1944; Oliva, 1954). Some use has been made of counting from airplanes or streambanks (with or without the use of intermediate step of photography). Techniques have also been tried which employ cameras of both film and television kinds, photoelectric eyes, telescopes, and diving apparatus. Swimming of transects by free divers, singly or in large teams, is a recent development of some promise for waters of sufficient clarity. Seining, trapping, or angling to the point of repeated no return has been employed but has not been tested extensively as to absoluteness.

Methods of indirect, numerical approximation, mostly involving mark-and-recapture, have been summarized repeatedly in recent years (*e.g.,* Ricker, 1948; DeLury, 1951; Lagler, 1952; Rounsefell and Everhart, 1953; Crowe, 1953); they have also been widely used in inland waters (Carlander, 1955) and in a few marine populations. Game biologists have employed similar means, *e.g.,* Lincoln Index (Lincoln, 1930). The techniques of indirect estimation of absolute population or standing crop are of two kinds. One depends on the diminution of catch per unit of effort as a result of population reduction by fishing. The other is based upon appearance of previously marked fishes in the catch. Of the two, the former, or DeLury regression method, is most recent but can be applied only infrequently. The method employing mark-and-recapture records may involve either a simple direct-proportion estimation (by the Petersen, 1896, formula) or a modification of this direct-proportion device based on summations of mark-and-recapture records during the course of netting operations (the formulas of Schnabel, 1938, Schumacher and Eschmeyer, 1943, or Chapman, 1951).

LABORATORY MODELS

Realizing that we and many of our colleagues have accepted in certain most useful of the foregoing techniques the theoretical proposals of mathematicians and have applied them to biological situations of essentially unknown characteristics, we have used experimental models to investigate the behavior of the proposed routines (somewhat as done by DeLury, 1947 and 1951). We judge that workers would be well advised to study such models and erect ones of their own based on field data to determine normalcy of empirical findings.

In our models, the "lake" was an ordinary minnow live-pail of two-gallon capacity, with a hinged cover and internally added baffles (like those inside a conventional, present-day cement mixer). In this "lake," known populations of 2,000, 5,000, and 10,000 "fish" were used in different experiments. The "fish" were graded, dry, white navy beans of nearly uniform size (beads of quite uniform size might have been better, although we could not detect any sampling bias with the beans). In these models, where the "fish" needed to be marked for recognition on recapture, previously dyed beans were substituted for the white ones. Our "net" for fishing was a measuring spoon of a size selected to obtain in one dip the number of beans desired as "catch" per unit of fishing effort. In the first run of the first experimental model (see Fig. 3), we used as a unit of catch the chance number of beans our chosen spoon held. The numbers thus obtained per dip varied from 28 to 49, and averaged 36.9. In all other trials we used fixed numbers in the catch. The sample-catch sizes thus employed were 10, 40, and 100; for each the number was composed of the first beans to make it up when they were poured from the spoon into a metal counting trough (a paddle designed to take only the desired number, as used by DeLury, 1951, might have been better). Accurate counts of large numbers of beans were facilitated by using boards countersunk with known numbers of holes of a 1-bean capacity each. Counting was also facilitated by hardboard strips with bean-sized serrations of known numbers along one edge.

Indirect, sampling methods of population estimation have certain requirements or assumptions. These are better met in experimental models than in nature; this fact makes the use of models ideal for understanding estimation methodology and for testing assumptions engendered in field applications. At least in our experimental models we are freed from problems of bias in sampling and all of the vagaries of working with living animals. It may be expected that the models then indeed will show performance of the mathematical theories.

INDIRECT METHODS OF ESTIMATION

The DeLury regression method uses catch-per-unit-of-effort data to estimate population. Unfortunately the procedure is inapplicable unless decrease in population due to fishing is reflected in decreasing take per unit of fishing effort; the fishing must take a significant part of the population. When it does, the decrease in catch-effort is proportional to the extent of depletion. Calculation of the regression formula for the data and use of the formula to compute the point of intercept with the x axis provide an estimate of the population. Obviously, a more rapid means of estimating the numbers in the population is to graph the data and by inspection to fit the expected straight regression line (Fig. 1). The catch per unit of effort (or individuals taken per sampling trial) becomes the ordinate and the total catch to and including the latest sample becomes the abscissa, in our example. Extrapolation of the regression line (picked subjectively or by formula) to its intercept with the x axis gives a value which is the approximation of population number.

Requirements (assumptions) of the regression method as adopted from DeLury, its proposer, in 1947 are: (1) The population is closed, that is, the effects of migration and natural mortality are negligible. Restriction of time interval for estimate to smallest practicable would almost always help meet this requirement. Adjustment for mortality, etc. is possible in some population data (Rounsefell and Everhart, 1953). (2) The units of effort employed do not compete with one another or else they are constant during the period involved. (3) The response of the fish to the gear, *i.e.,* their "catchability," remains constant for the period under investigation.

In an example with beans, starting with a known population (P) of 5,000, and fishing at the rate of 100 per sample, the regression was well established after as few as ten samples. Using data from seventy trials the formulary values for the regression become C (the catch per effort, *i.e.,* white beans per sample) = 102.54 — 0.020631 P, and a line fixed by the method of least squares, when extrapolated to its intercept on the x axis, gives an estimate of P very close to the known 5,000 (Fig. 1). Calculated population on this basis is 4,970. In the drawing of samples, the known population of 5,000 was composed of white beans. Each unit of fishing effort withdrew 100 beans but white ones

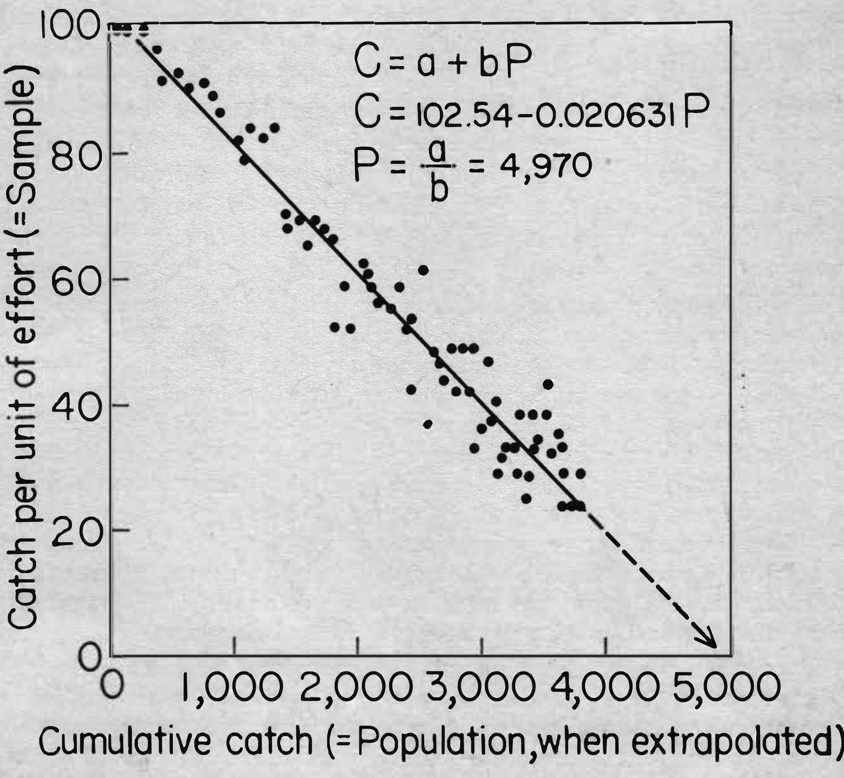

Figure 1. Graphic representation of relationship between catch-effort and cumulative catch, and extrapolation (dash line) to give an estimate of population by DeLury (1947) method, where C = catch per unit of effort, and P = population.

drawn in each sample were replaced by colored ones; the colored replacements merely had the effect of space in reducing subsequent catch of white ones. To assure randomness, the beans were thoroughly mixed between each pair of samples by ten revolutions of the minnow-pail "lake" on its side.

The indirect estimation of population by mark-and-recapture involves: (1) the capture and liberation of a number of marked fish (m) into a population; (2) the subsequent capture of numbers of marked (r) and unmarked (u) fish from the population; and (3) the computation of population size from the proportion of m, r and u by $P = m(u + r)/r$. The Petersen method is this formula in its simple form, and is applicable where a large number of marked fish is first liberated, after which a substantial sample is drawn for the proportion of u to r. The confidence limits of such estimates of P can be determined by reference to a table of expected numbers for binomial distribution which will give the expected limits of r in relation to u (Snedecor, 1946, Table 1.1; Adams, 1951). The Schnabel, the Schumacher and Eschmeyer, and the Chapman formulas are modifications of the Petersen method which make use of accumulating values of u and r during the processing of a large population of marked individuals (m) present. Thus the latter methods make it possible to estimate populations in instances where netting effort is relatively at a minimum; *e.g.*, in large lakes.

The foregoing four mark-and-recapture methods are based on the following assumptions: (1) that marked fish retain their marks throughout the period of estimation and are recognized on recapture; (2) either that marked fish are randomly redistributed throughout the population, or that netting effort is proportional to population density throughout a body of water; (3) that marked and unmarked fish are equally susceptible to capture; (4) that the population is a closed system without recruitment by growth or immigration; and (5) that loss by mortality or emigration is proportionately the same for marked and unmarked fish. If any of the foregoing are not met in field experiments, knowledge must be obtained for the development of correction factors if resultant values of P are to be satisfactory.

Population estimates by the mark-and-recapture method, which are being made by fishery workers, generally take the above assumptions into account. Estimates made during the spring or fall months in temperate waters tend to minimize the factors of recruitment due to growth, and mortality due to netting and marking. Fin-clipping and intensive netting for a population estimate within a period of 30 to 50 days, during the non-growing season, assure the retention of a mark during the period of estimation. Netting at numerous stations selected at random and the liberation of marked fish at the station of capture tend to assure random distribution of marked fish and their subsequent random recapture. Fin-clipping, as opposed to tagging, is believed not to affect the susceptibility of the marked fish to recapture as compared to unmarked fish. Where population estimates are made by netting concentrated in a short period of time (a month or so) and during a non-fishing season, mortality due to angling or natural causes is minimal.

The laboratory experiments with colored beans, in which we have eliminated most of the sources of bias which might be present in a field population estimate of fish in a lake, presumably reflect the variability of estimates which come solely from the probabilities of drawing representative proportions of marked beans. Thus the bean experiments give results which set the minimum limits of accuracy of field operations—the latter can be no more precise than the bean experiments, and will be as good as the experimental results with beans only if the necessary assumptions of uniform catchability and proportionate sampling of marked and unmarked fish are satisfied in field operations. If we examine Figures 2 to 7 (estimates by Schnabel formula), which give the results of 12 experimental runs with marked beans, some inferences can be drawn as to the number of days required to obtain a "good" estimate; furthermore, this time period can be related to sampling intensity. We here define a "good" estimate as one which approaches population size within limits of approximately ± 5 per cent. This is a realistic goal in our present state of lake-fish management. Also, the estimation must reach a stage of leveling off, in a day-to-day sequence, forcasting relatively little subsequent change if extended in the future.

For population of 5,000 and a sample size of 10 (Fig. 2) the curves for the two (duplicate) tests converge to a reasonably accurate estimate of P at about the 57th trial (day) and level off thereafter. We therefore take 57 days as the minimum period necessary for "good" estimates in this trial with P = 5,000 and S = 10 (sampling rate,

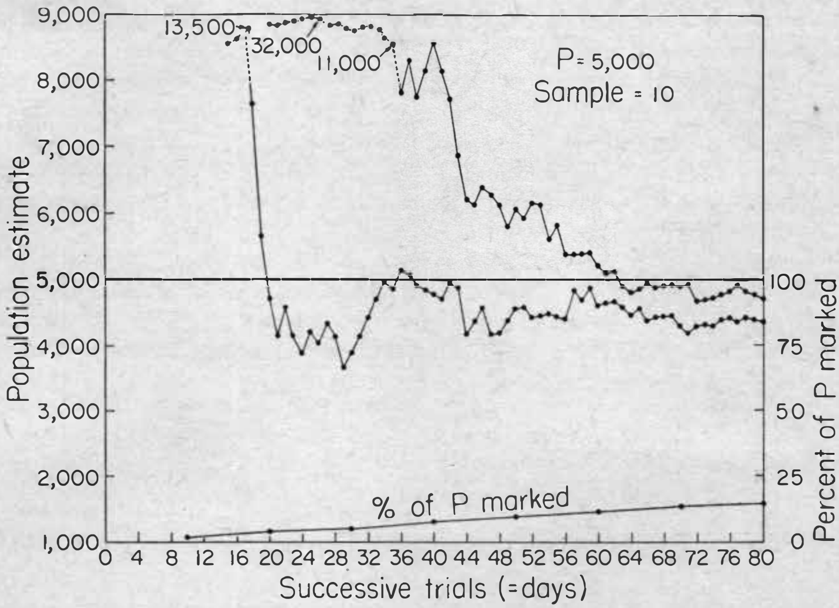

Figure 2. Population estimates on successive trials in two models using Schnabel (1938) on a known population (P) of 5,000, fished at the rate of 10 per sample.

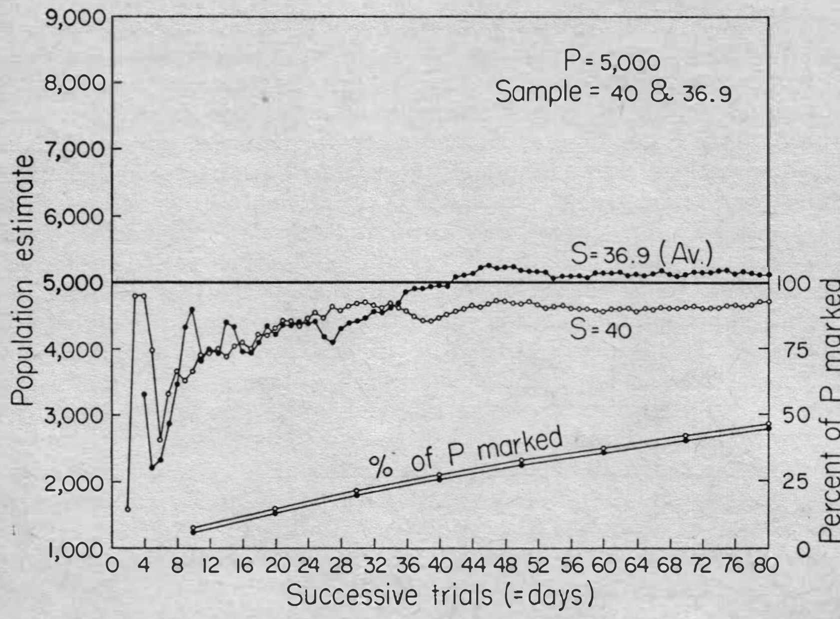

Figure 3. Population estimates on successive trials in two models using Schnabel (1938) formula on a known population (P) of 5,000, fished at the rates of 36.9 (average) and 40 per sample.

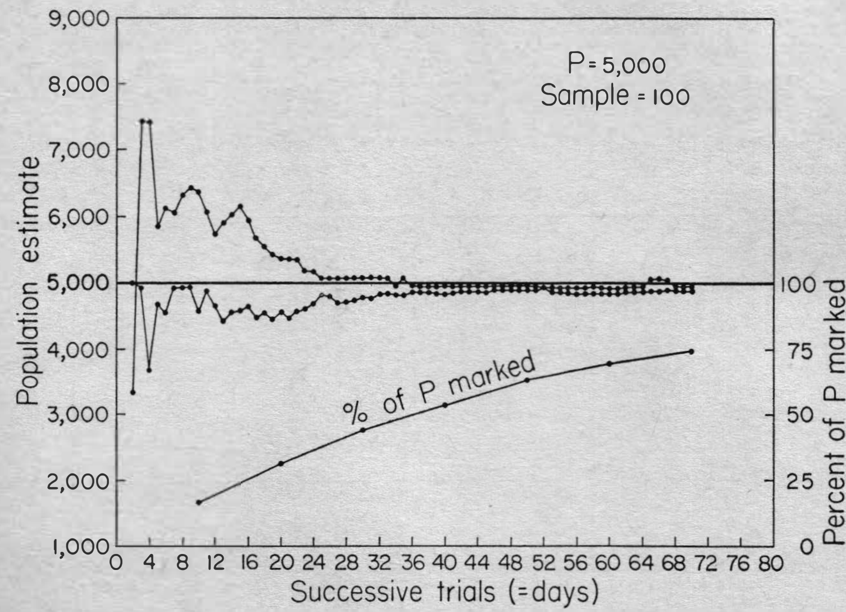

Figure 4. Population estimates on successive trials in two models using Schnabel (1938) formula on a known population (P) of 5,000, fished at the rate of 100 per sample.

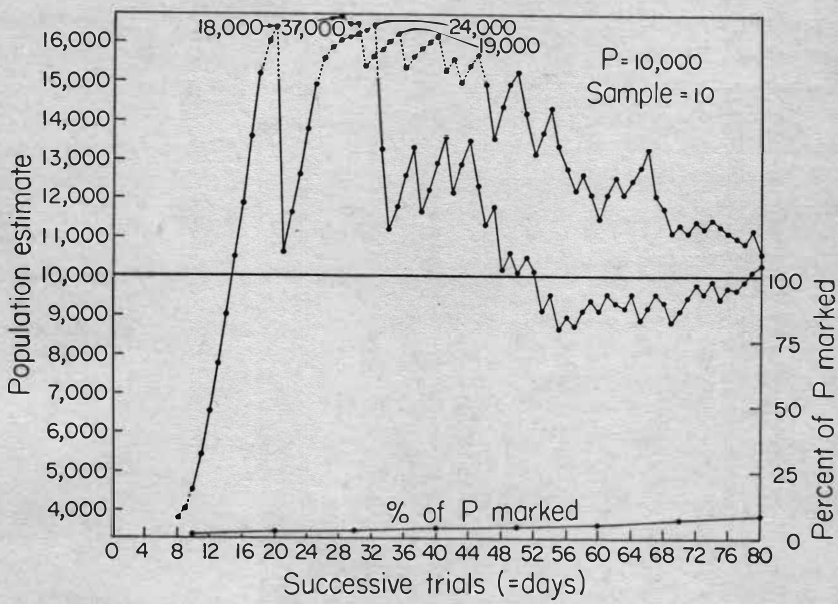

Figure 5. Population estimates on successive trials in two models using Schnabel (1938) formula on a known population (P) of 10,000, fished at the rate of 10 per sample.

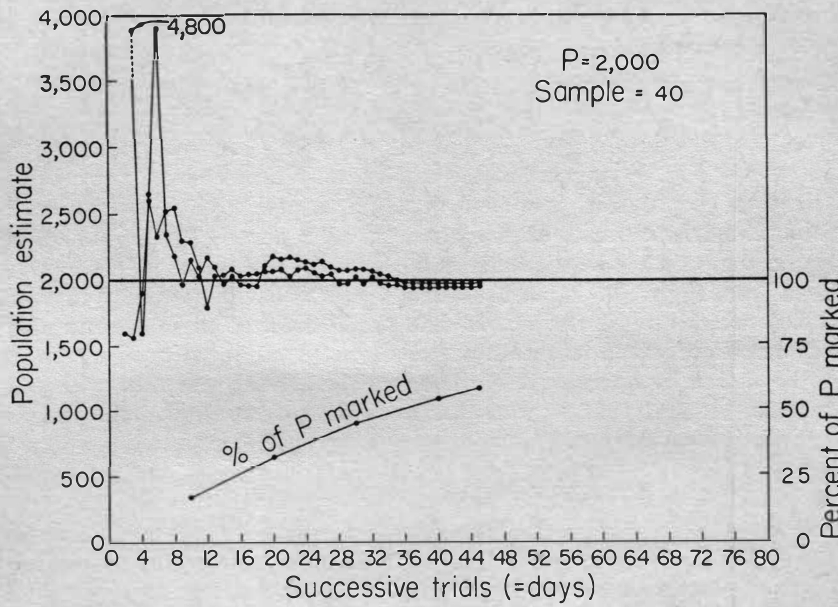

Figure 6. Population estimates on successive trials in two models using Schnabel (1938) formula on a known population (P) of 10,000, fished at the rate of 40 per sample.

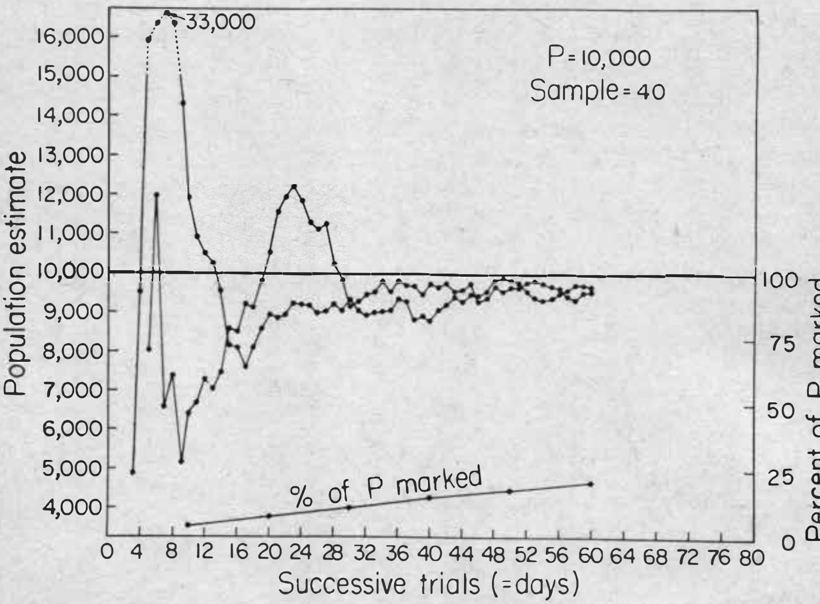

Figure 7. Population estimates on successive trials in two models using Schnabel (1938) formula on a known popullation (P) of 2,000, fished at the rate of 40 per sample.

0.2%). Similarly, for P = 5,000 and S = 40 (sampling rate, 0.8%) (Fig. 3), a good estimate was obtained in about 42 trials (days); for P = 5,000 and S = 100 (sampling rate, 2.0%), it was in 24 days; etc. For these six pairs of bean tests (Figs. 2 to 7), sampling intensity is expressed as the proportion of P captured in individual trials (days). The relationship of days required for a "good" estimate to sampling intensity (Fig. 8) appears to be curvilinear. Where about 2 per cent of the total population is taken in daily captures, a good estimate is obtained in about 20 days; when only 0.1 per cent of P is caught daily, the estimate requires about 80 days; intermediate values can be read from Figure 8. A mathematical proposal has been made (Fredin, 1950) which would render possible the identification of the number of samples required to obtain a "good" estimate (quality of goodness to be chosen by operator). We have not tested this proposal with our models but feel that it warrants attention of workers employed in population estimation.

PETERSEN METHOD USED ON STREAMS

Population estimates on fish in streams are being made by the simplified Petersen method. One approach is by the use of an electric

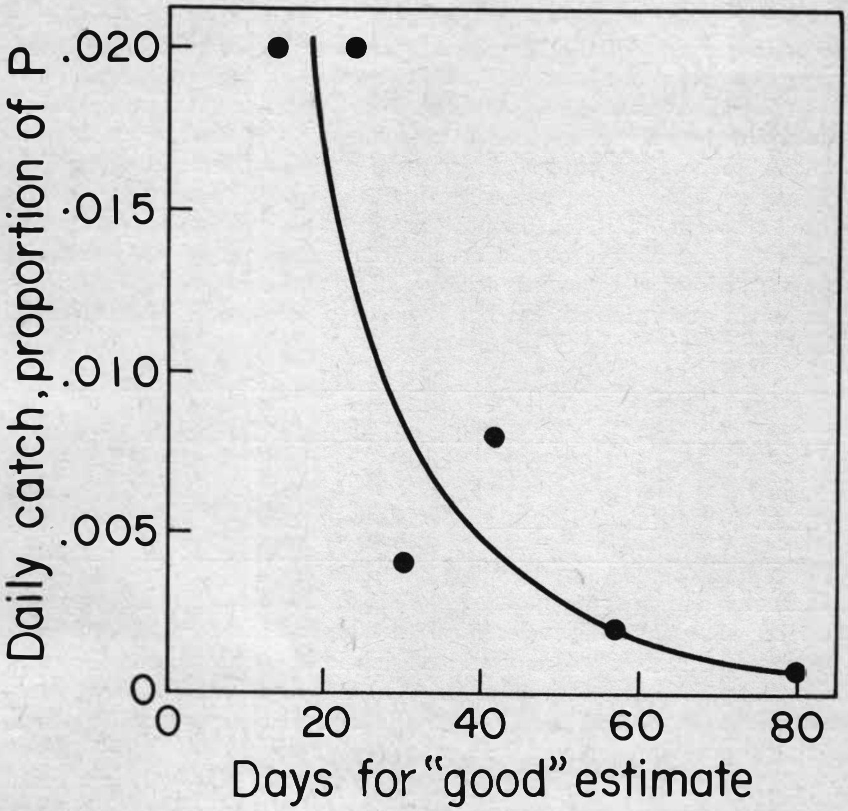

Figure 8. Time to a "good" estimate of population (P) as shown by relation of sample size (in decimal fractions of P) to days. Drawn from data represented in Figures 2-7.

shocker, with which a field party operates throughout a given length of stream; on a first "run" through the stream section, fish are captured, marked by fin-clipping, and released, giving a known number of marked fish (m) present; on a second run through the same stream section, the numbers of recaptures (r) of previously marked fish and the numbers of unmarked fish (u) are recorded. The shocker crew may capture from 10 to 30 per cent (more or less) of all fish present, in either run. It must be assumed, in computing $P = m\ (u + r)/r$, that u and r fish are equally susceptible to recapture in the second run, and generally this assumption on fin-clipped fish in streams has not been questioned. However, it has been shown that stream trout vary considerably in their susceptibility to capture in relation to size of the fish. A shocker crew in any particular run may capture only 5 to

10 per cent of the very small trout present while they are capturing 40 to 50 per cent of the large trout present. The large fish are more completely electro-narcotized and are easier to see and to capture than the small ones. The combination of length-class intervals introduces a systematic error, and the magnitude of this error is in proportion to both the extent of grouping and the degree of difference in susceptibility to capture according to size. Estimates which are based on a combination of length class intervals over a wide range are likely to be grossly wrong. The amount and source of the error are illustrated by the following example of hypothetical data; this illustration in quite elementary, but is perhaps worthwhile in connection with the remainder of this discussion:

Size group, in inches	Efficiency of shocker %	Pop. size (hypothetical)	First run (m)	Second run u + r	Second run r	P
2-4.9	5	10,000	500	500	25	10,000
5-6.9	10	5,000	500	500	50	5,000
7-9.9	15	1,000	150	150	22.5	1,000
10-12.9	20	200	40	40	8	200
Totals	....	16,200	1,190	1,190	105.5	......

Assuming the above population of 16,200 fish, and with variable shocker-collecting efficiencies of 5 to 20 per cent for different size groups, the numbers of m, u and r fish will be as above, and for each size group the value of $p = m\ (u + r)/r$ is as above. But if we combine the values of m, u and r for the four size groups and make a single population estimate, $p = m\ (u + r)/r = (1{,}190)\ (1{,}190)/105.5 = 13{,}423$; we underestimate the population (16,200) by 17 per cent. This underestimation is simply a mathematical error resulting from combining groups which are different in their susceptibility to capture. To a lesser degree there is also a systematic error within each of the four size groups assuming that susceptibility to capture varies within each size group.

To pursue this problem of bias as related to size difference in susceptibility to capture, on a more realistic basis, we employ field data given by Cooper (1952) for trout in a 4.8-mile section of the Pigeon River in Michigan. He found that the total population of brook and brown trout over 2 inches in length, in the 4.8 miles (24.1 acres) of river, was about 10,000 fish (average for two years). His tables show that the efficiency of capturing fish by shocker varied considerably according to size of fish, and his population estimates were (properly) based on three or four size groupings of the data. We herewith show that a further correction for the size difference in catchability should be made in population estimates of this type.

Values given in Cooper's tables on the percentage of recovery (*i.e.*, catchability) for trout of different size groups are plotted on Figure 9, and an approximate regression line, $Y = -5 + 4.22\ X$, is drawn by inspection. Cooper made his population estimates by combining fish in several size groups, 2.0"-4.9", 5.0"-6.9", etc. A further refinement would be obtained by grouping the fish into one-inch classes, 2.0"-2.9", 3.0"-3.9", etc. Thus from the regression line of Figure 9, shocker efficiency for each one-inch interval is determined—5.5% for 2.5" (mid-point of 2.0"-2.9"), 9.7% for 3.5", etc.; values given in Table 1. In the 4.8 miles of the Pigeon River, Cooper found a population of about 6,600 trout 2.0"-4.9", 1,500 fish 5.0"-6.9", 800 fish 7.0"-9.9", and 150 fish 10.0" and larger. These population figures are represented by horizontal lines on Figure 10. The curves drawn on Figure 10 are

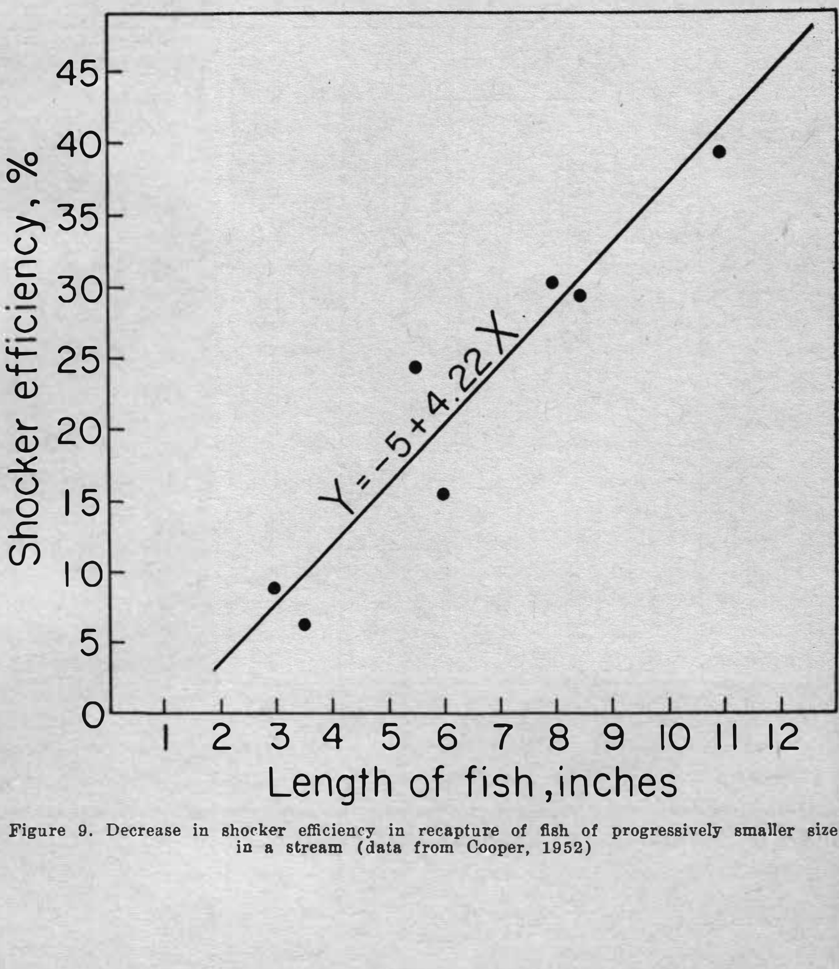

Figure 9. Decrease in shocker efficiency in recapture of fish of progressively smaller size in a stream (data from Cooper, 1952)

estimates of probable actual size-frequency distribution within the population—either a simple curve (Type A) or a polymodal curve (Type B). We then, for each of these curves, measure the ordinate of the curve for the mid-point of each one-inch class interval, convert these ordinate values to percentages for the entire curve, and use these percentages for determining numerical size-frequency distribution for a population of any given size. Assuming a population of 10,000 fish, the size-frequency distribution for the Type A and Type B curves of Figure 10 are given in Table 1.

We now have a fairly realistic size-frequency distribution among a population of 10,000 fish and practical values on shocker efficiency in capturing fish of different sizes. For these capture efficiencies (Table 1), theoretical computations are made of the number of trout taken

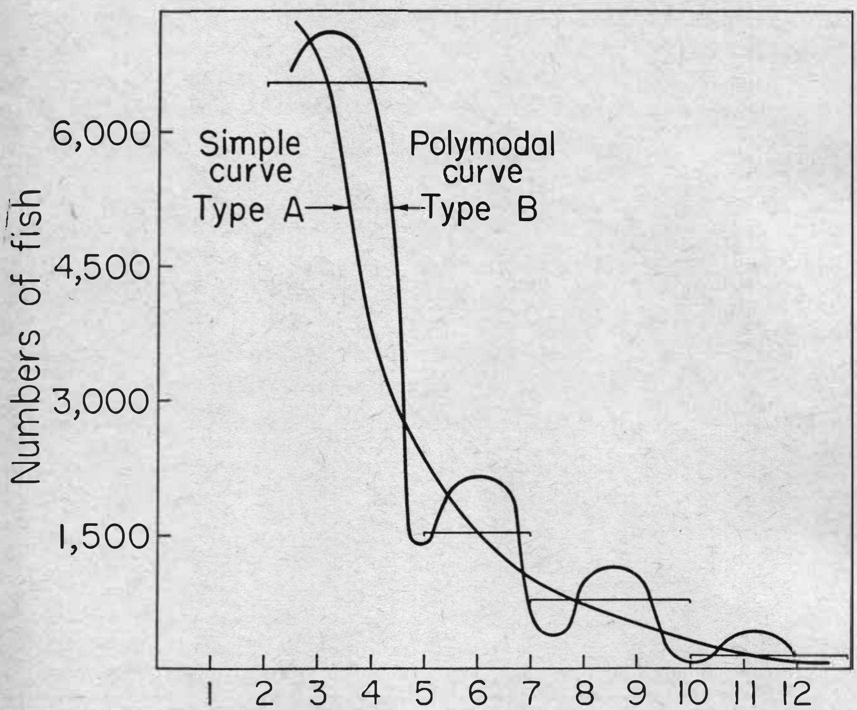

Figure 10. Curves of size-frequency distribution of a trout population, Pigeon River, Michigan (hypothesized from Cooper, 1952; horizontal bars represent his data on size range and frequency): A. Simple curve exemplary of a unimodal relationship; B. Polymodal curve illustrating modality of successive age groups.

TABLE 1. DATA FOR FISH-POPULATION ESTIMATES BASED ON ONE-INCH SIZE CLASSES, MODIFIED FROM COOPER (1952) FOR PIGEON RIVER

		Curve Type A				Curve Type B			
Size interval, inches	Shocker efficiency, %	Population	First run, *m*	Recaptures, *r*	*p*	Population	First run, *m*	Recaptures, *r*	*p*
2-2.9	5.5	3,450	189.7	10.43	3,450	2,760	151.8	8.35	2,760
3-3.9	9.7	2,590	251.2	24.37	2,590	2,930	284.2	27.57	2,930
4-4.9	13.9	1,440	200.2	27.83	1,440	1,740	241.9	33.62	1,740
5-5.9	18.2	880	160.2	29.16	880	820	149.2	27.15	820
6-6.9	22.4	560	125.4	28.09	560	840	188.2	42.16	840
7-7.9	26.8	430	115.2	30.87	430	150	40.2	10.77	150
8-8.9	31.0	300	93.0	28.83	300	470	145.7	45.17	470
9-9.9	35.1	190	66.7	23.41	190	70	24.6	8.63	70
10-10.9	39.3	110	43.2	16.98	110	70	27.5	10.81	70
11-11.9	43.6	40	17.4	7.59	40	140	61.0	26.60	140
12-12.9	47.8	10	4.8	2.29	10	10	4.8	2.29	10
Totals	....	10,000	1,267.0	229.85	10,000	10,000	1,319.1	243.12	10,000

during a first run and marked (m), and of the expected number of recaptures (r) in the second run. Since shocker efficiency is assumed for this example to be exactly the same for the first and second runs, $m = u + r$, and the formula for population, $P = m\ (u + r)/r$, becomes $P = m^2/r$; in Table 1 we do not need to list u values. Values of population (P) computed from values of m and r for each inch class (Table 1) correspond exactly with the initial population figures, as would be expected. But when the figures for m and r are combined into groups each of which covers several inch-class intervals (Table 2), and when population estimates (P) are based on these group totals of m and r, the group estimates are consistently in error in

TABLE 2. DATA FOR FISH-POPULATION ESTIMATES BASED ON VARIOUS DEGREES OF GROUPING DATA. FOR TYPE A AND TYPE B POPULATION DISTRIBUTIONS, SEE FIGURE 10.

Population distribution	Grouped class intervals for pop. estimate, inches	First run, fish marked (m)	Second run, recaptures (r)	Pop. est., based on groups	Sum of pop. est. by 1-inch class intervals	Under-estimate by grouping	Percent under-estimate by grouping
Type A	2-4.9	641.1	62.63	6,562	7,480	918	12.3
	5-6.9	285.6	57.25	1,425	1,440	15	1.0
	7-9.9	274.9	83.11	909	920	11	1.2
	10-12.9	65.4	26.86	159	160	1	0.6
	Totals	1,267.0	229.85	9,055	10,000	945	9.5
	2-6.9	926.7	119.88	7,164	8,920	1,756	19.7
	7-12.9	340.3	109.97	1,053	1,080	27	2.5
	Totals	1,267.0	229.85	8,217	10,000	1,783	17.8
	2-12.9	1,267.0	229.85	6,984	10,000	3,016	30.2
Type B	2-4.9	677.9	69.54	6,608	7,430	822	11.1
	5-6.9	337.4	69.31	1,642	1,660	18	1.1
	7-9.9	210.5	64.57	686	690	4	0.6
	10-12.9	93.3	39.70	219	220	1	0.5
	Totals	1,319.1	243.12	9,155	10,000	845	8.5
	2-6.9	1,015.3	138.85	7,424	9,090	1,666	18.3
	7-12.9	303.8	104.27	885	910	25	2.7
	Totals	1,319.1	243.12	8,309	10,000	1,691	16.9
	2-12.9	1,319.1	243.12	7,157	10,000	2,843	28.4

underestimating population size. For example, for the Type A population curve, the estimates involving four groupings (2″-4.9″, 5″-6.9″, etc.) give a total population of 9,055 fish which is 9.5% below the actual population of 10,000. When only two groupings were used for all fish, from 2″ to 12.9″, the total population was estimated as 8,217, an underestimate of 17.8%. An estimate for all fish (2″-12.9″) without sub-grouping gives an underestimate of 30.2%.

The extent of the underestimation resulting from grouping will depend upon the form of the population curve (compare estimates for curves Type A and Type B). The polymodal curve (Type B) gave better estimates than did the simple curve (Type A) because the higher portions of the polymodal curve corresponded closely to the length intervals of the groupings. If the size grouping for population estimates corresponds closely to modes in a polymodal size-frequency distribution of the population, the error of underestimation which is due to grouping will be reduced, but by no means eliminated. Under field conditions similar to those of the present example, population estimates based on grouping the records for size classes are underestimates for which the correction factor is about 10 to 20 per cent.

The systematic bias due to differential catchability, as illustrated above for a Michigan trout stream, undoubtedly operates, at least to some extent, in the case of catching such fish as bluegills, bass, etc. from lakes by trap nets, seines, or other methods. Similarly a bias in catchability might well occur as a result of the gear being more efficient in certain types of habitats than in others, as for example, an electrical shocker may be more effective in leading to the capture of all sizes of fish from a stretch of shallow riffles than from a reach of deep pools. Or, trap nets may fish more efficiently in open water than in a weed-choked area. Any such differential, no matter what the cause, is a systematic source of bias and should be appraised and corrected. Correction is ordinarily possible, because the investigator obtains, in the records of initial captures and recaptures, data for an appraisal of differences in catchability due to various factors; however, he must recognize the possible sources of bias. Wherever mark-and-recapture records are adequate for sub-grouping the data, the best estimate is obtained by summation of separate estimates based on the individual subdivisions. When mark-and-recapture records are not adequate for extensive sub-grouping, a correction for bias in catchability should be computed on a theoretical basis and applied. It seems probable that no estimate is without some bias because neither fish, fishing gear, nor fisherman are without "preferences".

It further seems inevitable that almost any carefully propounded correction will be better than none.

ACKNOWLEDGMENTS

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APPRAISAL OF METHODS OF FISH POPULATION STUDY—PART IV

DETERMINATION OF BALANCE IN FARM FISH PONDS

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American warm-water pondfish culture is concerned principally with the production of sport fishing, which is produced by the establishment and management of balanced fish populations. The simplest such combination and the one most widely used throughout the United States includes only two species—the bluegill, *Lepomis macrochirus*, and the largemouth black bass, *Micropterus salmoides*. Supplemental species that may be included with the bluegill and largemouth black bass are: the red-ear (shellcracker), *Lepomis microlophus*; the crappies, *Pomoxis* sp; the bullheads, *Ameiurus* sp; and the channel catfish, *Ictalurus lacustris punctatus* (Bennett, 1943; Swingle and Smith, 1942; Swingle, 1949; Toole, 1950).

Another type of population from which fish can be harvested was called an expanding population by Wood (1951). This he defines as an "assemblage of fishes rapidly expanding in numbers, average size and weight." Such a population is typical of those in new impoundments where the fish forming the original stock are relatively few in number. During the expansion, large numbers of small fishes are available. This is an ideal condition for production of a high poundage of piscivorous fishes—bass, crappies, walleye and others. In fact, for a short period, the expanding population usually produces a higher poundage of piscivorous fishes than a balanced population, because the latter maintains a high percentage of its total weight in large forage fish.

An expanding population may or may not result in balance, depending upon the method of stocking and other factors. However, by its expansion it has produced a crop of fish, principally the predatory species, that can be harvested. After these are harvested, the population can replace them in satisfactory sizes and amounts only if it achieves balance.

The fact that an expanding population within a given environment cannot continue to expand for more than one to two years limits good fishing for the bass and other predatory species to the second and part of the third year after expansion begins. Wood (1951) recommended extreme fluctuation of water levels to obtain periodic expansion. Bennett (1954) overcame the difficulty by draining Ridge Lake every other year, replacing only a small part of the population, and subsequently allowing it to expand. As a result of this procedure, the annual average catch in Ridge Lake varied from 10.9 to 30.0 pounds of largemouth bass per acre, with an average of 18.7 pounds per acre during 9 years of operation. The average combined catch of bluegills, green sunfish, and bullheads added an additional 12.5 pounds per acre per year. This emphasizes that such management is primarily for production of predatory species, in this case the largemouth bass.

In contrast, the balanced pond is operated for production of at least two species—the largemouth bass and the bluegill. It is stocked to produce the maximum poundage of each. During the first year after stocking, it is an expanding population and subsequently a balanced population. Following each harvest, it is to a certain extent again an expanding population, with the rate of expansion limited by the rapidity and extent of harvest (Swingle, 1950). Byrd and Moss (1956) reported an average catch per acre of 29.3 pounds largemouth bass plus 153.9 pounds bluegills, red ears, and bullheads in 11 state-operated lakes that were fertilized and that contained balanced populations.

Since balance is necessary within populations for continued efficient production and good fishing, the development of methods for measuring balance is essential for management. With the condition within the population known, management procedures may be applied to maintain high production.

Problems in pond management have been under continuous investigation in experimental ponds of the Agricultural Experiment Station of the Alabama Polytechnic Institute at Auburn, Alabama, since 1934. Investigations of the effects of various species, of balance, and of various corrective measures on annual catch have been conducted in experimental ponds at Auburn and in private ponds located in various parts of Alabama. During the past 17 years, a total of 189 annual catch records were obtained on experimental ponds that were open to public fishing. These ponds ranged from 1 to 26 acres in size. Records were kept on methods of stocking, manner of operation, catch per hour by fisherman, catch per acre, sizes of fish found in seining samples, composition of samples obtained with rotenone in selected ponds, and composition of the entire population at the end of each experiment. During the same period, examinations were also made of fish populations by seining and the results correlated with the fishing furnished in 121 private ponds. Parts of these studies relating to the determination of balance are presented in this paper.

Four methods for the determination of population balance presented here are: a seining technique called pond analysis, use of catch records, use of population values and ratios on complete populations and subsamples, and marking and recovery technique.

POND ANALYSIS

The first method, often called pond analysis, was reported briefly by Swingle (1945). It has been widely used by biologists in the investigation of ponds and lakes (Allen, 1950; Anderson, 1954; Holloway, 1951; Fredin, 1950; Fessler, 1950; Smith et al, 1955). Its usefulness has also been questioned on various grounds (Bennett, 1950). It has now been used over a 16-year period at Auburn and the conclusions concerning balance reached by this method have been found in agreement with the catch records and with the records obtained when the ponds were drained and all fish counted and weighed. It thus appears to be an accurate and usable method for determining balance within a short time and without destruction of the population.

The condition of balance is deduced from the degree of success of reproduction of bass and bluegills and the abundance of the 3-, 4-, and 5-inch groups of bluegills. Consequently, it is necessary that the factors affecting reproduction and growth of these fishes be understood so that correct conclusions may be reached. Since the basic factors underlying the method have not been published previously, they are given here.

FACTORS AFFECTING THE REPRODUCTION OF BLUEGILLS AND LARGEMOUTH BASS

1. *Size of brood fish:* There is a size below which bluegills and bass do not spawn. Bluegills making rapid growth have been found to spawn at a size of 0.3 ounce (3-inch group) if other conditions are favorable. Largemouth bass failed to spawn in the presence of bluegills unless they had reached a size of 6 ounces (9-inch group) by spawning time.

Also, as the size of the brood fishes increased, the numbers of young produced increased, other factors being equal. In a series of nine ponds, each stocked with uniform-sized brood bluegills varying from 1 ounce to 4 ounces in weight, the numbers of young produced during a 10-month period were determined by draining the ponds at the end of the experiment. The coefficient of correlation between initial size of brood bluegills and number of young produced per female was r = 0.95. The average number of young produced per female was approximately 70 for the 1-ounce bluegills and 2,560 for the 4-ounce bluegills.

This factor must be considered in pond analysis. Failure of largemouth bass to spawn in a 2-year pond may be because they were unable to grow to a 6-ounce size prior to the spawning period. This in turn indicates overstocking—too many fish for the available food. It may also indicate marginal waters for bass—those too cold for satisfactory growth.

Also, other factors being equal, heavy reproduction indicates large brood fish.

2. *Food available during the period of egg-formation:* Availability of food during the period of egg formation and maturation within the female was also found to be an important factor influencing the number of young fish produced per female.

A series of 18 ponds was stocked with brood bluegills of a uniform size of 0.08 pound in January. Rates of feeding were varied and the availability of food was measured by the growth of brood fish during the experiment. The growth ratio of the brood bluegills was expressed as their final weight divided by their original weight; this ratio varied from 0.3 to 2.4 in this experiment. After 10 months, the ponds were drained and the numbers of young bluegills determined. The coefficient of correlation between rate of growth of brood bluegills and the number of young produced per female was r = 0.71. With the lowest growth ratio the production was 5 young per female, and for the highest 116 per female.

Additional experiments with brood bluegills of various sizes indicated that, with brood bluegills 0.2 pound in size, those losing weight produced no young, those with growth ratios of 1.0 produced 700 young, and those with a growth ratio of 2.0 produced 1,700 young per female.

This information is used in pond analysis. Heavy reproduction by bluegills is taken to indicate rapid growth of the brood fish, light reproduction to indicate slow growth, and no reproduction to indicate no growth or loss of weight by the brood fish.

It should also be remembered that bluegills are able to form and mature eggs in a short time—approximately one month at water temperature above 80° F. and two to three months at 65° to 75° F. The extent of reproduction by bluegills, therefore, is the result of conditions in the population only one to three months prior to spawning. For instance, bluegills have been crowded and unable to reproduce in July, but following thinning with rotenone, they have spawned heavily one month later.

Largemouth bass require a much longer time for egg development. Egg sacs begin swelling in September or October with eggs matured and ready to lay the following April at Auburn. Reproduction by bass, therefore, is influenced by conditions during the fall, winter, and spring.

3. *Crowding:* Since crowding results in less food per individual, its effect is reflected in both smaller size of brood fish and in slower rate of growth. Crowding may result from too many individuals of the same species and/or of competing species. The effect of crowding by individuals of the same species usually appears largely due to reduction in the food available per individual. As the extent of crowding increases, growth retards, then stops, and finally the individuals lose weight. The lack of reproduction by bluegills, for instance, is very commonly caused by the presence of so many individuals of this species that none can grow. Similarly, too many bass, too many bullheads, or too many individuals of any one of the other pond fishes have been found to reduce or prevent reproduction by their own species.

Crowding due to competing species obviously may be expected to have similar effects. Large numbers of bullheads have prevented not only spawning by bullheads, but also spawning by bluegills, red ears, and similar species within the same population. Large numbers of crappie have prevented spawning by crappie, and also spawning by bluegills. Consequently, the lack of spawning by bluegills may be due either to crowding by bluegills or to crowding by a competitive species.

4. *Egg-eating habit:* Under conditions of crowding bluegills have been found to eat eggs of their own species and those of other species (Swingle and Smith, 1943). Where confined to the eggs of bluegills and competing species, this may be considered a beneficial type of birth control. However, when extended to include the eating of eggs of the largemouth bass, it is extremely detrimental as it causes unbalanced populations. Where bluegills were not crowded and had adequate food for growth, however, both bass and bluegills were able to reproduce adequately. Old balanced ponds in Alabama have been found to produce adequate hatches of largemouth bass and bluegills yearly for 10 to 15 years.

Lack of reproduction by bass may, therefore, result from crowding by bass, or from crowding by bluegills. The latter in turn may be due to too many bluegills, or to other species competing with bluegills.

5. *Repressive factor:* The apparent excretion of a hormone-like repressive factor that prevented reproduction was first observed in goldfish, carp, and buffalo populations (Swingle, 1954 b, 1956). When these fishes were stocked in ponds several months prior to the spawning period, reproduction did not occur when the water temperature rose to the normal spawning temperature. However, upon transfer of these fish into adjacent ponds filled with fresh water, spawning usually occurred within 24 hours. When the water in which a goldfish population had been kept for several months was pumped into adjacent ponds, brood goldfish in these ponds failed to spawn until this water was completely drained and the pond refilled with fresh water. Heavy spawning of many species at periods of rising water in the spring is probably related to this factor.

It was suspected that the presence of such a repressive factor controlling reproduction was widespread among fishes. There is some indication of its presence in bluegills. In 21 experiments containing bluegills only, the young produced per female was found to vary inversely with the number of brood fish per acre, with $r = -0.63$. This relationship existed even where the number stocked could not be considered crowding. However, the effect of a repressive factor upon bluegills, if present at all, is insufficient to prevent reproduction before these fish become so crowded that none can grow.

Some evidence exists that reproduction of largemouth bass may be partly controlled or prevented by a repressive factor excreted by bass. After bass have ceased to reproduce in hatchery ponds, additional spawns may often be obtained by transfer of the brood fish into another pond freshly filled with water.

In case of the bluegill, it appears that it may excrete a repressive factor that inhibits spawning of largemouth bass. It was originally thought that the egg-eating habit of crowded bluegills was alone responsible for the failure of largemouth to reproduce in unbalanced populations. However, it was later found that crowding of bluegills also prevented largemouth from laying eggs. Here was a condition in which bass were not crowded, were growing at a rapid rate, but still could not reproduce because of overcrowded bluegills. Some of these bass from crowded bluegill populations were induced to spawn lightly one month after the regular spawning period by transferring them into ponds filled with fresh water. This is a problem much in need of investigation.

In all experiments containing the two species, there appears to be an inverse relationship between the number of bluegills per acre and the number of young bass produced, a fact also noted by Bennett (1954). Whether this is due to a definite repressive excretion from bluegills affecting reproduction of bass can only be determined by carefully controlled experimentation. However, extremely heavy reproduction by bass is correlated with the presence of no or few bluegills, moderate reproduction with balanced populations of bass and bluegills, and a lack of reproduction is often due to overcrowded bluegills.

6. *Water temperature:* For each species there is a minimum temperature at which reproduction occurs. With certain species there are normal pond temperatures above which reproduction does not appear to be possible. For instance, the largemouth bass lays eggs when water temperatures rise to between 68° and 75° F. in the spring. Eggs retained beyond this temperature appear to liquify and to be resorbed. Occasionally bass spawn in the fall when the water temperature drops to between 75° and 68° F.

For pond analysis by seining, however, it is more important to know the minimum temperatures at which the first young can be caught in the spring—that is, the water temperature when the first young have hatched and risen from the nests. This information for many pondfishes has been obtained in experimental ponds at Auburn and is presented in Table 1.

TABLE 1. TEMPERATURES OF THE SURFACE WATER OF PONDS AT AUBURN, ALABAMA, WHEN THE FIRST YOUNG FISH HATCH IN THE SPRING

Species common name	Scientific name	Water temperature at 6-inch depth. °F.
Bass, largemouth	*Micropterus salmoides*	70-74
Bluegill	*Lepomis macrochirus*	80
Bullhead, speckled	*Ameiurus nebulosis marmoratus*	80
Carp	*Cyprinis carpio*	74
Crappie, white	*Pomoxis annularis*	68
Crappie, black	*Pomoxis nigro-maculatus*	68
Fathead minnow	*Pimephales promelas*	60-65
Goldfish	*Carassius auratus*	60-65
Golden shiners	*Notemigonus crysoleucas*	68
Green sunfish	*Lepomis cyanellus*	68-70
Pickerel, Eastern	*Esox niger*	55-60
Round flier	*Centrarchus macropterus*	60-65
Shellcracker (red-ear)	*Lepomis microlophus*	75
Warmouth	*Chaenobryttus coronarius*	80

For example, the minimum temperature of the surface waters at a 6-inch depth when the first young bluegills could be found is given as 80° F. This then adds another step in pond analysis. If bluegills have failed to spawn, the water may be too cold. Ponds in northern latitudes or at high elevations may never become warm enough for successful spawning by bluegills (Swingle, 1949; Fuqua, 1947). However, if the water temperatures have risen above 80° F., failure to spawn would be due to other reasons.

7. *Silt-laden waters:* Waters heavily laden with silt are apparently unsuitable for spawning by bass and bluegills. Bluegills can apparently reproduce in somewhat more heavily silt-laden waters than bass. Consequently, the silt load may be such that there are young bluegills but not bass, or none of each species. Many such ponds will be found to contain only bullheads, as these fish are apparently able to reproduce under such conditions. Windswept ponds in clay soils in the West, gully ponds in fine clay areas of the Midwest, and small shallow ponds continually muddied by hogs or other livestock are types of silt-laden pond waters in which bass and bluegills are unable to reproduce.

8. *Water fluctuation:* The fluctuation of water levels in a pond due to planned drawdowns, drought, or other reasons may affect the ability of bluegills and largemouth bass to reproduce. A drawdown when bass are on beds may prevent hatching. Drawdown during the summer months may crowd bluegills to such an extent that they are unable to spawn. A severe drawdown during the fall, winter, and spring followed by rising water in the summer may result in no hatch of bass and followed by heavy reproduction by bluegills, thus causing an unbalanced population.

It also appears probable that a heavy drawdown during the spring followed by rapidly rising water during or just prior to the bass spawning period may result in heavier spawning of bass due to release from the repressive factor. The possibilities along this line are in great need of investigation. Holloway (1952) has reported the use of a temporary drawdown for correction of unbalanced populations.

9. *Salinity:* While the exact limits of salinity beyond which largemouth bass and bluegills fail to reproduce is not known, it appears that bass can reproduce at a slightly greater salinity than bluegills. Water with salinities 5°/°° (5,000 p.p.m.) and above are apparently unsuitable for reproduction by either species. W. W. Neely (private communication) reported bluegills dying at 7.9°/°° in South Carolina ponds. Such salinities may be looked for in coastal ponds, and in ponds supplied from deep wells in certain areas.

10. *pH of water:* Bluegills and largemouth bass spawn sparingly in waters with pH of 5 to 5.5, and fail to spawn entirely at lower pH values. Alkalinities in excess of 10.0 to 11.0 also appear toxic to young of both species.

11. *Light:* No work of a definite nature has been done on the effect of light upon spawning of bluegills and largemouth bass. In

the case of bass, however, it has been repeatedly noted that they spawn earlier in clear water than in waters colored with phytoplankton or with suspended clay. Spawning in muddy ponds has been as much as 30 days later in the spring than that in clear ponds at Auburn.

METHOD OF POND ANALYSIS FOR BALANCE

This method is for use in pond populations that contain largemouth bass and bluegills, and those that also contain other supplemental species. The pond populations should be of sufficient age that an equilibrium has been reached between the weight of fish and the available food supply. It would yield relatively little information the first summer following stocking—the period of rapid population expansion when no balance has been established. During the second summer, however, the pond population normally ceases to expand and reaches an equilibrium with the food supply; the capacity to replace the harvested fish is then dependent upon the state of balance within the population. Pond analysis, therefore, is principally for use in populations during their second summer or older. Seining for analysis is principally confined to the summer months, during the spawning period of bluegills. In Alabama, this is during the period of June to October.

The equipment needed is a 6- or 8-mesh minnow seine 15 feet long and 3 feet deep and a 2-mesh larger seine 50 feet long and 6 feet deep. Seining is done at intervals around the pond by anchoring one end at the bank, pulling the seine straight from the bank to its full length, and then sweeping in an arc back to the bank. Thus a quadrant area is seined. This enables quantitative estimates of numbers to be compared.

A few hauls with the minnow seine normally is sufficient to detect whether a population is balanced or unbalanced. The 50-foot seine is used principally to corroborate the conclusions reached from the results with the small seine, and to determine the presence of competing species. It is also helpful in obtaining a better quantitative idea of the abundance of intermediate bluegills. In late summer, when young-of-the-year bass have reached larger sizes and are difficult to catch with the minnow seine, the larger seine is useful in determining their relative abundance.

Three terms used in the analysis should be defined. Recently-hatched bluegills refer to those less than 1 inch in size that have apparently hatched within the preceding month. In the early spring, young bluegills that hatched the previous fall may be difficult to distinguish from those recently hatched, but differ in that the latter are more translucent, thus enabling one to see the vertebrae through the flesh. The second term, intermediate bluegills, refers to those in the 3-, 4-, and 5-inch groups. The third term, young bass, refers to fry or fingerling young-of-the-year of the largemouth bass.

RESULTS OF SEINING AND THEIR INTERPRETATION

Every group of fish and other aquatic animals caught in the seine can yield information concerning the population. It is important to note the numbers of various species, the inch-groups to which they belong, recent hatches, and the condition of the fish. In addition, the presence or absence of underwater weeds, filamentous algae and heavy silt loads, water temperature, pH, volume of flood waters, and other factors yield important information to the biologist in determining the reasons for various conditions of balance and in determining management procedures.

The following key will be an aid to biologists in determining balance, with the headings listing the species and groups of fishes caught in the minnow seine. Under each heading is given the interpretation and the condition of population balance. This is followed by the catch to be expected in the big seine for each state of balance.

I. NO YOUNG LARGEMOUTH BASS PRESENT:

A. *Many recently hatched bluegills, no or very few intermediate bluegills.*

Under condition I, all of the factors that can prevent reproduction of bass must be considered: water temperature too cold, water too heavily laden with silt, water drawdown during spawning period, water too saline, pH in unfavorable range, bass too small to spawn, bass too crowded to spawn, spawning prevented by egg-eating or repression due to overcrowded bluegills or to crowding by competing species.

In relation to these causes must be considered the information under section I A and the common factors that could cause both conditions.

First, since bluegills hatched, the water was not too cold for bass to hatch; also, heavy reproduction by bluegills does not go with water heavily laden with silt, and such a condition can be readily observed. There could have been a water drawdown during bass spawning, with subsequent rising water during bluegill spawning; the presence of inundated dry-land plants would substantiate such a theory and additional information could be obtained from the pond owner.

Since bluegills reproduced, the water was not too saline for bass to reproduce; also, for the same reason, the pH was not in a range unfavorable for bass spawning. Since bluegills spawned heavily, this indicated that bluegills were not crowded and thus did not prevent bass spawning. This would leave one reason for this condition—bass too crowded (or too small as a result of crowded bass) to spawn. The fact that no or very few intermediate bluegills could be found is also an indication of crowded bass.

Condition: Temporary balance, with bass crowded.

This condition is called temporary balance because no young bass were found. It may result from bass being so crowded that they did not reproduce, or a lesser crowding in which spawning occurred with the young bass subsequently eaten by the older bass. Such ponds may go into good balance subsequently or into unbalance if too many bass die or are harvested before reproduction can occur the following year.

Such a population produces bluegills of large size and good condition, but bass of small size and poor condition.

Where this is the status of the population, the average catch in Alabama ponds with the 50-foot seine is five or less intermediate bluegills in good condition per quadrant, with bass less than one pound and in poor condition. The average number of intermediate bluegills per haul may vary somewhat with different fertility levels, different climatic conditions, with differences in the depth of the shallow water areas of ponds, and the amount of cover available in the area seined.

B. *No recent hatch of bluegills, many intermediate bluegills.*

Here again factors that may cause both conditions under section I and I B must be found. The water could be too cold for either bass or bluegills to spawn. This can be determined by checking the temperature with a pocket thermometer. If it is above 74° F., bass could have spawned and if above 80° F., both species could have spawned. Waters heavily laden with silt could cause the condition. If the pond level is extremely low, this could be responsible due to crowding all species.

Since intermediate bluegills were present, bluegills had spawned previously which indicates salinity was probably not the cause of the trouble. A pH unfavorable to spawning could be the answer. Normally, this occurs only in polluted waters, in some bog-water ponds, ponds near smelters, or strip-mine ponds. If acidity is suspected, the pH can be easily checked. If the pH is above 5.5 and below 10.0, another reason for lack of reproduction must be sought.

The bass are not crowded or they would not have allowed large numbers of bluegills to escape into the intermediate group. This leaves overcrowded bluegills as the cause, and the presence of large numbers of intermediate bluegills confirms this conclusion.

Condition: Unbalanced population with overcrowded bluegills.

In such a population, the bass are usually few, large and difficult to catch because of the large supply of overcrowded bluegills available for food. The bluegills are thin, small, and, after the crowded condition has existed for some time, they become so weak and listless that practically none can be caught by hook and line.

When this is the status of the population, the average catch in the 50-seine is in excess of 35 intermediate bluegills per quadrant haul and often runs up to several hundred per haul. Bass, if caught at all, are usually in excess of 1.5 pounds and in very good condition.

C. *No recent hatch bluegills, many intermediate bluegills, many tadpoles and/or minnows and/or crayfish.*

This is obviously the same as the previous condition, with either the tadpoles, minnows, or crayfish also present. Large numbers of these animals caught in a small seine are always an indication of extremely few laregmouth bass or no bass, as they are apparently eaten in preference to bluegills.

Condition: Unbalanced, overcrowded bluegills and very few bass.

The catch in a 50-foot seine would be similar to that under section B.

D. *No recent hatch bluegills, few intermediate bluegills.*

The reasoning is similar to that of section I C. Each cause for the lack of reproduction by bluegills and bass must be considered: temperature, silt, drawdown, salinity, and unfavorable pH. If these can be disregarded, then there remains the fact that bluegills are crowded as indicated by no recent hatch; the presence of only a few intermediate bluegills suggests that the crowding is due to some competitive species that can not be taken readily with a small seine, such as bullheads, crappie, sucker, or shad.

Condition: Unbalanced population, crowding due to species competitive with bluegills.

This conclusion should immediately be checked by use of the large 50-foot seine when possible, or by questioning the owner as to the presence of other species, and preferably by both procedures. When the competitive species are in deeper water, extensive seining is often required to catch only a few even in populations where they are crowded. The condition of those caught should be observed and will indicate the extent of crowding. If bullheads or crappies are involved, they will appear in the catch by hook-and-line, while gizzard shad and suckers seldom are caught in this manner.

E. *No recent hatch bluegills, few intermediate bluegills, many intermediate green sunfish.*

This is a very common condition usually caused by green sunfish invading the pond prior to stocking bass.

Condition: Unbalanced, crowding due to green sunfish.

The average 50-foot sein haul will usually contain in excess of 50 intermediate bluegills and green sunfish per quadrant. Bass, if caught, will be large and in good condition; bluegills will be small and in poor condition.

F. *No recent hatch bluegills, no intermediate bluegills.*

Condition: Unbalanced or possibly no fish present.

This is often due to water too cold for bluegill-bass combination, too saline, or too heavily laden with silt.

II. YOUNG LARGEMOUTH BASS PRESENT:

A. *Many recently hatched bluegills and few intermediate bluegills.*

In this case it is obvious that no condition interfering with reproduction of either species occurs. The hatch of bass indicates the brood fish are growing and were not crowded during the winter or spring. The recent hatch of bluegills indicates that this species is growing and is not crowded. Since there are few intermediate bluegills, this indicates that bass were adequately thinning the young bluegills by predation, but leaving some to replace the harvested fish. Thus, the conditions for balance are being satisfied—reproduction to supply the young fish, thinning to prevent overpopulation, and growth by intermediate and older fish of both species to insure successive yearly harvestable crops.

Condition: Balanced population.

There are, of course, various stages within balance. These can be judged in part by heaviness of recent bluegill reproduction, number and condition of the young bass, and by the relative numbers and sizes of intermediate bluegills.

With this condition, the average catch in the 50-foot seine is between 5 and 30 intermediate bluegills per quadrant haul. The upper figure may occur in high-producing ponds following heavy harvest, but is more commonly associated with the more inefficient populations within the balanced range with F/C = 5 to 10 and A_T below 50 (Swingle, 1950). In such a case, the number of newly-hatched bluegills found with the small seine is relatively low compared with that found in the more efficient ponds. The best populations appear to be those averaging 10 to 18 intermediate bluegills per 50-foot seine haul and with heavy recent bluegill reproduction showing in the small seine.

The minimum abundance of young bass considered adequate for good balance is an average of 1 bass per 3 hauls of the minnow seine during the first half of the summer and 2 per haul of the 50-foot seine during the latter part of the summer.

B. *Many recently hatched bluegills; very few or no intermediate bluegills.*

This again is a variation of section I A, crowded bass, as shown by the lack of intermediate bluegills. However, it is considered balanced because young bass were found. This condition is often considered desirable where ponds are operated for bluegill fishing as it results in bluegills of large size. It may result from overstocking bass, from the pond having steep sides and lack of cover for small bluegills, and from very restricted fishing or no fishing for a period of a year or more in an originally well-balanced pond.

C. *No recent hatch of bluegills; no intermediate bluegills.*

This condition, with bass able to spawn but bluegills unable to spawn, is not common.

Condition: Unbalanced population.

This could, of course, result from the absence of bluegills. However if bluegills are present, the common causes of this condition are:

1. The water may become warm enough for bass spawning, but too cold for bluegill spawning (below 80° F.). Such a condition occurs in some ponds in northern states, in some high-altitude ponds, and in some ponds receiving large amounts of cold underground water.
2. The salinity could be such that bass, but not bluegills, could spawn. This was found in some slightly brackish ponds along the Gulf. The exact salinity tolerance for each of the two species is unknown.

D. *No recent hatch bluegills; few intermediate bluegills.*

This indicates primarily a condition of crowding of bluegills by a competitive species that developed subsequent to the bass-spawning period; such a condition may result from bullheads or shad growing to a competitive size following their recent introduction. It could also result from a reduced food supply to bluegills subsequent to bass spawning, caused by one of these conditions: greatly lowered water level, failing to fertilize pond second year following adequate fertilization the first year, feeding fish in the spring followed by cessation of feeding, and similar situations.

Condition: Temporary balance, with possibility of unbalance developing unless condition responsible is soon corrected.

The 50-foot seine here is useful principally in determining the relative numbers and sizes of the intermediate fish, the condition of the bass, and the presence of other species.

SUMMARY OF POND ANALYSIS

The foregoing key to conditions must be used with care. It must be understood that populations vary to such an extent that all gradations between the above conditions can be found. However, this method has been found to be a very useful tool in diagnosing condition of balance and in determining the corrective measures necessary to improve fishing in undesirable populations. It is rapid and often yields as much usable information as a complete inventory of the pond population.

DETERMINATION OF BALANCE FROM THE CATCH

Balance is defined as a condition within a fish population that results in sustained annual crops of harvestable fish satisfactory in amount in relation to the basic fertility of the body of water containing it (Swingle, 1950). Obviously, therefore, catch data may be used as a measure of balance providing the productivities of desirable populations under similar conditions of fertility are known, and providing the fishing effort is sufficient to harvest the available crop. At Auburn, balanced unfertilized populations yielded an annual average catch of approximately 20 pounds of fish per acre, and balanced fertilized ponds yielded 150 to 200 pounds per acre, where fishing effort was adequate. Unbalanced ponds under similar conditions yielded 19 to 100 pounds per acre per year. However, in well-balanced fertilized ponds with restricted fishing the catch varied from 50 to 150 pounds per year and did not measure the capacity of the ponds to produce. Consequently, no interpretation of condition of balance is possible from annual catch data with only yields per acre known. Similarly, average catch per unit effort without equivalent effort per acre cannot be a measure of the productivity or state of balance of populations in various bodies of water.

In ponds open to the public, it is relatively easy to tell balanced from unbalanced ponds—almost no fishermen are seen fishing the latter. A simple test with a seine practically always shows that fishermen have detected an unbalanced condition when they stop fishing a particular pond. Such lack of fishing resulted from the unbalance and was not the cause of unbalance as is often claimed.

It is usually possible to tell balanced from unbalanced ponds containing bluegills and largemouth bass by questioning fishermen as to what they catch.

In unbalanced ponds, the catch is principally composed of small bluegills of the 3-, 4-, and 5-inch groups. With continued crowding, almost no bluegills will bite. No bluegill beds are located. The bass caught are few, but usually larger than 2 pounds.

In normally balanced ponds, most bluegills caught are above the 6-inch group in size. The average bass caught is from 1 to 2 pounds, but smaller and possibly larger ones are also taken. Bluegills are found on beds several times during the spring and summer.

In ponds crowded with bass, almost all bluegills caught are large fish, averaging in excess of 0.3 pound. They are found on beds several times in the spring and summer. The bass caught average less than 1 pound and are in poor condition.

DETERMINATION OF BALANCE FROM POPULATION VALUES AND RATIOS

The relationships and dynamics within balanced and unbalanced fish populations and the ratios and values measuring balance have been described (Swingle, 1950). This information was derived by draining 85 ponds and by poisoning four ponds that had yielded satisfactory and unsatisfactory catches of fish. The species were then sorted, placed in inch-groups, counted and weighed. From these data, six population values were derived that taken singly and collectively measured the state of balance. These were F/C and Y/C ratios, and the A_T, A_F, I_F, and S_F values.

Only two of these will be considered here, the F/C ratio and the A_T value. Taken together, they offer a good measure of the condition of balance of a population.

The F/C ratio is the ratio between the total weight (F) of forage fish (bluegills) and the total weight (C) of piscivorous fish (bass) in the population. While balanced and unbalanced populations occurred up to F/C = 10, higher ratios occured only in unbalanced populations. In balanced populations the most efficient were in the range F/C = 3 to 6, and those from 1.4 to 2.0 were crowded with bass.

The A_T value is the percentage of total weight in the form of fish of harvestable size, and is, therefore, a measure of the efficiency of a population. Below A_T = 33 lie the unbalanced populations, from 33 to 40 the inefficient borderline populations, and above 40 the balanced populations. The most desirable range between 60 to 85, with overcrowded bass populations between 80 and 90.

With draining or complete poisoning of a pond, the species can be sorted to sizes and the stage of balance expressed accurately by the population values. This is mainly useful as a post-mortem upon the population, however. The population values have been used to check the conclusions from pond analysis, the results of experimental stocking, thinning, and for other purposes. They have also been used to express the composition of subsamples in ponds, rivers, and large impoundments (Swingle, 1954a).

SUBSAMPLING OF POPULATIONS TO DETERMINE BALANCE

Subsamples of populations for determining composition and balance are commonly made by sampling selected area with rotenone, electricity, or by seining. The samples taken are hoped to be representative of the entire population. It can be taken as axiomatic that the whole is dissimliar to any of its parts, and that, as a result, subsamples cannot accurately represent the whole. Each segment of the entire population, however, is in part the result of the remainder. Consequently, samples can be made to yield certain types of information. Pond analysis, for example, is relatively accurate because the samples are considered from the standpoint of the conditions within the entire population that could result in such samples. It makes no attempt to assume that the sample is a replica in miniature of the entire population.

The results of sampling ponds with rotenone, by seining, and by pond analysis were compared with the entire populations obtained by complete poisoning and by draining selected ponds. Two examples representative of the information obtained follow.

In a 2-acre pond stocked with bluegills, warmouth, and chain pickerel, few fish could be caught during the third summer after stocking. The catch consisted of intermediate bluegills and warmouth, with very few large bluegills. The sample taken with a minnow seine contained no recent hatch of bluegills, pickerel, or warmouth, but contained many intermediate bluegills. By pond analysis it was rated, therefore, as an unbalanced population with crowded bluegills and lacking adequate predatory fish. The population was then estimated by seining and by rotenone poisoning of subsample areas. The fish obtained were counted, placed in inch-groups, and weighed. The pounds per acre, the A_T value and the E value (percentage of total population by weight) for each species was then computed. The results were as follows:

Method	Pounds per acre	A_T	E values Bluegill	Warmouth	Pickerel
Rotenone sampling 0.14 acre	12.4	17.6	96.4	2.8	0
3 seine hauls 50′ x 6′ with 0.5 mesh —0.135 acre	20.6	25.0	85.7	14.3	0
Total population	411.9	5.7	83.5	16.5	0

All methods agreed on three things. The population was unbalanced, it was crowded with bluegills, and it was lacking in predatory fish. The greatest error was in the estimation of pounds fish per acre from the rotenone and seining samples. This was undoubtedly due largely to unequal distribution of fishes over the pond area. Also, the estimates of species composition and the A_T values varied because species and sizes of fish were not uniformly distributed—a fact well known to fishermen.

In a 22-acre pond containing bluegills, shellcrackers, green sunfish, and largemouth bass, few fish of any kind could be caught. Minnow seine samples included many intermediate bluegills, but no recent hatch of bass or bluegills. It was rated by pond analysis as an unbalanced pond. The population was then thinned by marginal poisoning with rotenone (Swingle, Prather, Lawrence, 1953), killing thousands of intermediate bluegills. Marginal poisoning was repeated until the average number of intermediate bluegills caught in the 50-foot seine was 18 per seine haul, indicating that the pond, while unbalanced, had the intermediate fish adequately reduced. Two 1-acre areas were then sampled with rotenone to estimate the population, and the pond subsequently drained and the total population determined. The results were as follows:

Method	Pounds per acre	F/C	A_T	Number per acre Intermediate bluegills	Bass
Rotenone sampling 1 acre	57.0	40.7	31.1	864	92
Rotenone sampling 1 acre	45.0	55.3	22.4	1,046	36
Total population	94.7	39.7	14.2	788	48

All methods agreed again that this was an unbalanced population. There was also apparent agreement with the seining results that the intermediate bluegills had been reduced adequately. Even though the sample areas included one-eleventh of the total pond area, pounds per acre was greatly underestimated and the estimates of the average number of bass per acre varied greatly.

Obviously, these samples inaccurately represented the exact composition of the entire population from which they came. As the samples in these cases represented 7 and 9 per cent, respectivly, of the total pond areas, it would not appear probable that larger areas or more areas could be sampled by poisoning without serious injury to the population as a whole. However, by converting the information gained into population values, they did measure within usable limits the state of balance in each case. Thus, sampling provides a usable check upon other methods of estimation.

MARKING AND RECOVERY METHOD

This method is widely used in estimation of fish populations in oceans, lakes, and to some extent in ponds (Shoemacher and Eschmeyer 1943; Carlander and Lewis, 1948; Fessler, 1950; Fredin, 1950; Ricker, 1948). It attempts, by adding a known to the unknown population, to increase the accuracy of the estimate. The known is theoretically the number of marked fish. A basic assumption is that following the process of capture, marking, and release, these fish suffer no greater rate of mortality than the rest of the individuals in the population (Ricker, 1948). As it is practically impossible to seine or trap bluegills without causing increased mortality, such a condition is seldom, if ever met. Another basic assumption is that the marked fish become randomly distributed throughout the population. This is asking quite a bit of the marking technique, as this would then appear to be the only portion of the population thus distributed.

Partly as a result of starting with improbable assumptions, but largely due to the inherent difficulty that the part must be assumed to represent the whole, estimates of populations by the marking and recovery method are seldom closer than those obtained by seining or poisoning, Table 2. The contributions of many biologists to the study of subsampling and population estimations offer promise that improved methods will be available in the future. This problem is one of the most important to the future of fisheries management and should receive high priority in the allocation of research funds.

TABLE 2. FISH POPULATIONS ESTIMATED BY MARKING AND RECOVERY COMPARED WITH NUMBERS ACTUALLY PRESENT IN PONDS AT AUBURN, ALABAMA

Species	Pond size acres	Actual number	Per cent marked	Estimated by marking and recovery per cent of actual number
Bluegills	1.5	15,685	6.9	44.2
Round flier	1.5	265	39.1	223.7
Goldfish[1]	0.05	2,881	6.0	45.2
Goldfish[1]	0.008	178	9.2	32.6
Goldfish[1]	0.008	227	18.8	68.7
Goldfish[1]	0.008	282	22.6	67.3
Hybrid bluegill X green sunfish[1]	0.008	75	50.6	134.7

[1]From J. Carranza, 1953. Métodes para marcar peces de pequeño tamaño, de utilidad en estudios de poblaciones. Ann. Escuela Nacional de Cien. Biol. VII (1-4):111-128.

SUMMARY

Methods of determining balance in pond populations include: (1) seining technique called pond analysis, (2) use of catch records, (3) population values and ratios calculated upon the entire population and upon samples, and (4) the marking and recovery technique.

Pond analysis is a process of deduction of the state of balance from the degree of success of reproduction of bass and bluegills, and the relative abundance of intermediate bluegills. It is based on factors affecting reproduction: size of brood fish, food availability during egg formation, crowding by the same species or other species, egg-eating habit, repressive factor, water temperature, silt, water fluctuation, salinity, pH, and light. A key is given relating the kinds, sizes and numbers of fish caught in a minnow seine and in a 50-foot seine with 0.5-inch mesh to the state of balance of the population.

Balance was estimated from the sizes and kinds of fish caught by fishermen. In unbalanced ponds, the catch was principally intermediate bluegills with occasional large bass, and bluegills were never caught on beds. In balanced ponds, the catch was principally composed of bluegills larger than the 6-inch group, and bass from 1 to 2 pounds, with bluegills found on beds several times yearly. In ponds crowded with bass, the catch was composed of bluegills averaging over 0.3 pounds and bass less than 1 pound.

Population values were found useful in expressing balance, with the most valuable being A_T, the per cent by weight of harvestable sized fish in a population, and F/C, the number of pounds of forage fish per pound of piscivorous fish in the population.

Samples from use of rotenone or a 50-foot seine with 0.5-inch mesh gave low estimates of the pounds of fish per acre, but when converted into population values gave relatively accurate measures of balance.

Marking and recovery estimations of populations were inaccurate. This and other estimation techniques greatly need intensive investigation and development.

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DISCUSSION

CHAIRMAN KRUMHOLZ: Thank you very much, Mr. Swingle.

Now, I would like to have the members of the panel come up here and have a chair on the stage so that you can direct your questions to them.

MODERATOR EVERHART: I think generally, I would say amen to these four papers. I suspected this would be the high point of the conference for me, and I am speaking now as a fishery biologist, of course, so that we are ready now for any questions or comments from the floor.

DR. ALBERT HAZZARD [Lemoyne, Pennsylvania]: I would like to start with the last first, if I may. I am very curious about this repression factor Mr. Swingle mentioned. Do you have any idea as to the chemical given off by the fish?

MR. SWINGLE: We don't know what it is. We just know it is there. By assuming its presence, we are able to get fish to spawn when we want them to and also retard their spawning. We have taken buffalo fish, held them two months past their normal spawning period, and placed them in fresh water, and we can get them to spawn. We have done it also with goldfish.

DR. HAZZARD: Did you talk to chemists about it?

MR. SWINGLE: They have said a good protein chemist could probably work that out. We don't have a good one.

DR. WIEBE: You mentioned buffalo. How about carp?

MR. SWINGLE: The same factor is present in carp. You get heavy reproduction in the carp when the water is drawn down and you get a heavy influx of fresh water in the spring. There is some evidence that the bluegill exerts a repressive factor on the carp.

DR. WIEBE: We have been hopeful in our impoundment because of the winter drawdown, we would keep down the carp, especially in proportion to the buffalo. Apparently we are wrong.

MR. SWINGLE: If you bring the water level up during the spawning period, you are doing just the wrong thing.

DR. WIEBE: I am not convinced we are doing it entirely wrong because in the open sections of the reservoir we have a great deal of wind and wave action and that might probably be enough that this repressive factor would be diluted so it wouldn't be effective, and that with the drawdown, we destroy the vegetation and so forth. I am not convinced that we are completely wrong. I think there is something there in between.

DR. GEORGE W. BENNETT [Illinois]: Regarding this repression factor, I would like to ask Mr. Swingle what concentration of fish you must have in a body of water to reproduce this repression substance?

MR. SWINGLE: That apparently varies greatly with different species. With the carp for instance, it is hard to give numbers. Let's say with 50-carp per acre you could get spawning. With 200-carp per acre, you wouldn't get any. If you had a 10-carp per acre, you could leave them in a long period of time and wouldn't get repression. The buffalo fish are very sensitive to it. You could carry, let's say, 200 pounds of fish per acre in the lake and probably wouldn't get any spawning at all, except you have one more thing. Sometimes these fish spawn as they come out in the shallow water in the heavy downpours of rain which freshens the water.

DR. BENNETT: One other thing. Can you make estimates involving the weight of fish and produce this repression factor in a pond and then remove these fish and replace them with other fish of the same species, few in number, and still have their reproduction? There is no introduction of water from the outside.

MR. SWINGLE: We didn't do it that way. We took the water out of the pond containing goldfish and pumped it over to other ponds. These were stocked with goldfish but there was no production until the repressed water was replaced with fresh water. The check pond they reproduced the day after we put the fish in.

MODERATOR EVERHART: I was interested in the paper on the creel census method. I was trying in Maine to use this voluntary method, and it was our conclusion the only good creel census we get is when we have a good biologist taking the information, and we have had particularly good results with our fishing creel censuses. It wouldn't apply to the whole country, but it fills in nicely during the winter to have the fishery biologist working on the ice. They can canvass the fishermen very easily and we have gotten some good information with that type of creel census.

I wonder if there is any feeling about Mr. Cuerrier's conclusion that we should examine these creel censuses? What about West Virginia, Harry?

MR. H. VAN METER [West Virginia]: I was wondering about one thing. We have three types of creel censuses—the regular creel census, a selective creel census, and we have 50 fishermen who we know are better than the average anglers and this creel census is kept on their own and at the end of the census they send us their material.

Now, we know if they can't catch fish, we have something to worry about. But, we do use the selective creel census along with the record creel census, and then also we have been doing some aerial censuses. We feel, especially during the opening weekend of the trout season, that we can get a very good picture over the entire state.

We have ground crews taking creel censuses or biologists taking creel censuses, and we use that in conjunction, but the selective creel census is good public relations. We feel that our fishermen are honest and we can get pretty good records from some of the selective creel censuses. Of course, some of the fishermen do not take as many trips as some of the others, but they will average anywhere from 10 to 50 trips during a season. We feel that throughout the state they can get the picture through the better-than-average angler as far as catch is concerned.

DR. CARLANDER: I would like to invite anybody who can, to come to the symposium which Dr. Cuerrier mentioned, at the Iowa State College. We are having a symposium on the 19th of March, two weeks from today, on sampling methods for creel censuses. Actually, the program started as a small one within the department, and there was so much interest from outside, that we expanded it.

It will be open to anybody, for any discussion you want.

MODERATOR EVERHART: I not only stuck Jerry with the questions, but he gave me some questions to ask him and one of them was to explain to us the stratified method they are using at Michigan now.

DR. COOPER: I would like to say, Michigan is putting a lot of effort into the general census and we are very much interested in Dr. Cuerrier's remarks on the subject.

I think we have shared his point of view for some time, that the voluntary type of creel census which depends upon the cooperation of anglers to make out their own records and leave them at some checking stations, unless you have a department employee there to keep track of them, is not going to produce reliable returns.

The creel census work being carried on in Michigan at the present time—there are actually three types of censuses, a state-wide general creel census conducted by conservation officers, a sampling type of census for the state as a whole, and then at several of the state's experimental stations where they have very close control over a few individual waters, there is a checking station and department staff on hand all the time, where a creel census is a compulsory thing.

But, the question raised by Dr. Everhart is concerned with the type of census that we have going on quite a number of experimental lakes where we are evaluating either changes in fishing regulations or some other management practices being tried on an experimental basis. This would be regarded as a stratified type of sampling in so far as estimating the total angling pressure, the total fish catch and also in getting a measure of average fishing quality in terms of catch per hour.

We have about a dozen of these lakes with five men working on them full time. Each man is assigned to two or three lakes where he works on a schedule, a prearranged sampling schedule of checking. Say one man checks each of the two lakes about three days a week. That schedule is arranged so he is on some particular lake an equal number of Mondays, Tuesdays and Wednesdays, Saturday and so on, through all the portion of the season that the schedule covers. That sampling also accounts for the length of the haul, either with the number of boats with their anglers or the total time of anglers on the lake. That is done on an estimate pattern so we have an estimate through those counts of total angling density.

The same census man will contact quite a few hundred anglers as they leave the lake and get the record as to how long they fished, what they caught and what they used for bait and so on. But, that is the general outline of our intensive type of creel census that is being done on some of these lakes where we are trying to evaluate various experimental management procedures that Dr. Cuerrier referred to.

CHAIRMAN KRUMHOLZ: While Jerry is standing there, I would like to ask him a question. Do you have any thoughts on the relative merits of the different formulas you used in the population estimates, which of them are more reliable, which are the easiest to use and so on?

DR. COOPER: Well, the four formulas are about equal, so far as ease is use and in the computations on the calculators. I think you can see from the formulas themselves, they get progressively more involved, but actually the total amount of effort involved in the computation is small as compared to the amount of effort that would be involved in the field in a thirty-, forty-, or fifty-day run in a population estimate, so I don't think that the complication of the formulas should be a very important consideration.

The Petersen formula would be designed for a special type of instance where you can mark a whole lot of fish with a relatively small amount of effort and in an intensive sampling get a great, big sample from which to make your computation on sample size.

The Schumacher and Eschmeyer and Chapman formulas provide an easy method of computing the competence limit of your estimates, but you could also devise a formula to go along with the Schnabel one, too. Ricker pointed out one of those formulas is a little more precise when the proportion of marked fish in your population gets up close to 50 per cent and the other one more precise in a very much smaller percentage of marked fish. That factor probably should be given consideration.

Actually, we have in the 20 or 30 population estimates that we have made on Michigan lakes so far in the last ten years, regularly run the estimates by both the Schnabel and Schumacher and Eschmeyer formulas and we find so little difference in the actual estimates, we are pretty well convinced it doesn't make much difference which method you use. There is less difference between the two methods than is involved in the actual competence methods on your estimate.

MR. SWINGLE: I want to comment, probably you can get the greatest accuracy by using beans and leaving out the fish. Estimates vary from 30 to 50 per cent of what is there when we drain the pond.

MODERATOR EVERHART: On the age and growth, we have considerable trouble with the white perch and we have convinced ourselves we can read the scales accurately, but there is a state not too far from us that is just as sure they can read them, and we don't agree. And sometimes in instances with a fish as easy to read as salmon—easy in quotes—we sent known-age fish to other workers and we find their interpretations do not agree. I am sure we are wrong sometimes. We tried by using the scale projector, using two or three men working together. We think we can save considerable time and get our reading that way rather than by reading it at a different time.

DR. CARLANDER: You get two of them to argue out the points if there is a difference of opinion, rather than reading them separately and then arguing.

MODERATOR EVERHART: Right.

DR. CARLANDER: Well, I hadn't thought too much about that. The only thing I would say offhand on that is that as you argue it out, you may have one who is more or less dominant and suggests a criteria that is used by both of you while you are arguing it out so that you get a greater amount of agreement on the third and fourth scales than if you had read the two entirely independent of one another.

When you get through, there is no way of knowing what is right. Actually, I am much more surprised that the results come out so well, when you think of how many misinterpretations can come in scale reading.

DR. BENNETT: I don't believe there is any substitute for actual information on fish of known age, is there? In other words, two men might be arguing about the age of a fish from a population about which they knew nothing. They both could be very wrong.

DR. CARLANDER: Right.

DR. BENNETT: And the only safe answer is to actually know something about the fish of the very small sizes which we would consider fish of known age perhaps.

DR. CARLANDER: Where you can use a length frequency method, the length frequency method should be used as a verification of the scale method, I think in every possible study. I think that we should also try to get as much supplementary information to vertify the results as possible.

DR. BENNETT: Not only from the standpoint of the normal things that take place, but also from the standpoint of the abnormal things. For example, Larrimore, working on warmouth bass, had a sample of warmouth taken at a period when the pond owner was using a clam dipper around the edge of the pond and he found that that operation produced what looked like an annulus on the scales of most of those warmouth belonging to that population; so there are abnormal things that enter into the picture also.

DR. CARLANDER: That is very true, and where you collect the scales throughout the summer months, you may get some of the abnormal situations. When Bill Ziegler was working on the white bass, he found in one year most of his white bass did not make an annulus and if he had not been collecting throughout the year, there would be no way of knowing. We have to know that we are going to have some of these errors coming in.

DR. LAGLER: May I ask you a question? If we now have marvelous instruments like digital computers and these machines, why not answer Mr. Bennett's question by having you go to your engineering department and use some of those mechanical things with bells ringing and lights flashing, and we wil get ageing and calculated lengths just like that?

CHAIRMAN KRUMHOLZ: Sounds like automation.

DR. CARLANDER: I don't think that one needs answering.

TECHNICAL SESSIONS

Tuesday Morning—March 6

Chairman: Robert L. Patterson
Coordinator, Wildlife Restoration, Game and Fish Commission, Cheyenne, Wyoming

Discussion Leader: Bill T. Crawford
Game Research Supervisor, Missouri Conservation Commission, Columbia, Missouri

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UPLAND GAME RESOURCES

THE FARMER-SPORTSMAN PROBLEM AND A SOLUTION

Walter E. Howard and William M. Longhurst
University of California, Field Station Administration at Davis and Hopland Field Station at Hopland, California

The average sportsman of today has less difficulty escaping from the shackles of everyday living to go afield than he did a decade or so ago. His current problem is not so much when he can go, but ***where*** he can go without being engulfed by the growing army of outdoor enthusiasts. In the "good old days" he had no access problem, even if his favorite haunts were on private land, but now most of this private domain is closed to him. Consequently, the bulk of the wildlife resource is no longer available to the average sportsman, for the amount of private land in farm, forest, or range includes almost three-quarters of continental United States. It is equivalent to almost eight times the combined area of all the national forests. Unfortunately, no one knows how much private land is enjoying satisfactory utilization of its wildlife resources by sportsmen.

One of the main reasons why this vast area is closed to sportsmen is that new methods of regulating access privileges have not kept pace with the ever increasing hordes of sportsmen. Formerly, farmers seldom objected to an occasional sportsman. But now so many seek this form of recreation that landowners are literally forced to close

[1]In the absence of the author, this paper was read by Mr. Clinton Lostetter.

their land to free access. Some farmers have been invaded by so many "friends" that they have had to close their land completely, because it became too involved to allocate access privileges. Also, the "opening day" stampede creates many problems.

The crux of the private-land-versus-too-many-sportsmen dilemma is the management of access in a manner satisfactory to both sportsman and landowner. To do this it must be handled in a democratic and orderly manner. It must not be a burden to the farmer, and the simpler is its operation, the better. It must also be done impersonally, so that a landowner is not embarrassed if a friend is excluded. There must also be incentives that will encourage the landowner to open his property to others. The kind of incentive needed will depend upon local conditions, but one incentive frequently overlooked is the profit motive.

The regulation of access usually costs money. It seems reasonable, therefore, in such instances that payment for the management of access should come from the sportsmen rather than from farmers or public taxes. License fees will never be able to absorb the expense. Nevertheless, if we are to provide "bread for the many instead of cake for the few," it will often be necessary to develop fish and game on private land as a profitable agricultural crop.

And why not manage wildlife on private land as an agricultural crop? Wildlife species can no longer shift for themselves because of modern agricultural practices. On ranges and forests most game animals benefit from proper land use, since they thrive better in the earlier stages of plant succession than when climax vegetation develops.

Integrating wildlife management with other agricultural pursuits has become a complicated science. Many of the problems of wildlife—nutrition, reproduction, disease, and management—are similar to those of farm animals. No longer can wildlife be managed merely by enforcing laws and preserving wilderness. Agronomic training is needed to produce the necessary field crops for waterfowl and game. Water problems involve pollution problems, stream flow maintenance, pond construction, control of aquatic plants, and the irrigation of crops. A knowledge of both livestock and poultry husbandry is needed to manage deer and upland game. All aspects of habitat management—brush control, range reseeding, building up soil fertility, grazing management, agricultural engineering, and agricultural economics—are important in managing today's wildlife, especially on private land.

When so much of the wildlife resource is not utilized and is locked up in private land, other unfavorable situations develop. Unharvested fish and game are a temptation and frequently create difficult trespass problems. Surplus game often results in crop damage. Competition for forage between big game and livestock may likewise be increased, and in a few areas problems of disease and parasite transference to livestock have arisen. Deer, in particular, may become so numerous that they seriously damage their habitat. Game, in general, may be a rapidly renewable resource, but habitats, on the other hand, usually recover only slowly. Another danger of having so much of the resource locked up is that it becomes used as customer entertainment of big business, which then buys the choice remaining areas. Likewise, people are compelled to form expensive clubs in order to get this type of recreation. Also, public agencies are forced to purchase extensive holdings for the development of this resource, which, with tolerance and mutual understanding between sportsmen and farmers, can often be handled more economically on private land.

There is no good reason why the landowner should have to provide the labor and capital, as well as the land, without some benefit. As the farmer sees the picture, he feeds, raises, and protects the game, the state claims it and the sportsman gets it, while he gets only crop depredations and trespass problems. Remember, also, that some landowners are not interested in game. With them, in particular, a profit motive may be required before they will attempt to increase wildlife or allow its harvesting. Some, however, will want no part of wildlife or sportsmen even if there is a financial gain, while others will be more interested in order being established, with relief from trespass, than they will be in being paid for granting privileges of access to sportsmen.

Perhaps the main obstacle to developing game management as an agricultural resource on private land is that many people still believe this to be "commercialization" of the public's fish and game. This is really an unfair accusation. It always costs money to manage the access of large numbers of people. Look what it costs just to "preserve" our national parks. To encourage landowners to open their land to sportsmen for a fee is a calculated risk, naturally, for how can anyone predict that a profit motive among local farmers will always result in a greater production of wildlife and at the same time provide more recreation at a reasonable price for enough sportsmen to justify the program.

But what if some of the landowners accept the challenge of free enterprise and try to make a profit? If some farmers go into the business of wildlife management, perhaps then they will have an incentive not only to increase the density of fish and game, but also to preserve more wetlands, woodlands, and other marginal areas now labeled as worthless. And isn't this what sportsmen and nature-lovers want? It seems desirable or even necessary to create an economic interpretation for some of these intangible, "uneconomic" values of the wildlife heritage, at least on private land that is now closed to sportsmen. Since the unspoiled outdoors is vanishing rapidly, a yard-stick to measure the social, moral, esthetic, economic, and other values inextricably bound up with this sport is badly needed.

A person who now has a good place to go hunting or fishing free of charge may not like the fee approach, for he may fear that he might lose his setup. But, for him, it should be pointed out that the plan does not concern public and other areas that are now open to him. Furthermore, if much of the private domain that is now closed to him can be opened, it would greatly lessen the load on public lands and other open areas.

If sportsmen will genuinely encourage landowners to manage their wildlife as a business and cooperate with them in resolving the farmer-sportsman predicament, whole new vistas may open up. Free enterprise will stimulate all sorts of opportunities for sportsmen, and many different codes of ethics could be practiced. For instance, a landowner might stipulate that only flies or barbless hooks can be used, or establish an extra-large size minimum, or limit hunting to bows and arrows, or impose some other restriction. All of these methods would be designed to allow more people to partake of the sport, yet maintain the resource, since less fish and game would end up in the creel or bag. Obviously, all such stipulations by landowners would have to be *more* stringent than current state regulations, as far as the welfare of wildlife is concerned. Perhaps someday it may be considered more sporting to take less of the wild stock, to enjoy the activity for its own sake without feeling the limit has to be achieved.

Will a farmer be interested in managing his wildlife as a business? Yes, we think so, particularly if methods can be worked out that make it easy for him to regulate access privileges and reduce trespass. Practically all of the hunting in Texas, for example, is handled this way. Wyoming reimburses the landowner for antelope shot on his property, and there are other programs that have achieved varying degrees of success. The potential cash-in-pocket-value of the hunting and fishing resource—deer, waterfowl, bobwhite, quail, dove, pheasant, cottontial, bass, trout, crappie, catfish, and many others—is often greater than that derived from other current uses for such lands and waters, or at the very least will pay the taxes on the land. And, fortunately, agriculture and fish and game, when properly managed, are generally reasonably compatible on the same lands. Consequently, income derived from leasing access for hunting and fishing usually is in addition to that produced by other agricultural operations carried out on the same land. Furthermore, this income involves little or no capital outlay since in most instances the wild animals are already there.

Ingenuity on the part of landowners will determine the value of their wildlife resource. On an acre basis, waterfowl hunting usually has the greatest value. A good blind often brings in $200 a season. Hunting rights on western rangelands, particularly if the deer hunting is good, are sometimes worth 50 cents or more per acre or up to $10 per day per hunter, or $100 per season. The total hunting privileges per season on much of the ring-necked pheasant land is worth about $4 per acre. It is really impossible to put a price on the value of the privilege of access for hunting and fishing, because there are no fixed standards. Quality, a factor for which there is no suitable yardstick, is important. Proximity to human population centers increases the value. Frequently, however, if good will has been established through unselfish actions by sportsmen, they may find that the landowner does not want pay for the access privilege.

The type of services available on the area also determines what people will pay for their privilege of access. Cabins or other camping facilities are important. With waterfowl hunting, the existence of blinds, or permission to put them in, makes a pond worth more. Easy access to a place that gives the illusion of remoteness is always desirable. The availability of riding and pack animals is often an asset, particularly for big game hunting. Permission to use hunting dogs is a factor. Boats are an important part of lake fishing with many. In general, it might be said that most sportsmen really want to get out and rough it "in comfort."

Wildlife habitats can be improved in an infinite number of ways to increase productivity of fish and game. Advice and assistance on these matters and others concerning theoretical biology can be readily obtained from the many professional wildlife managers in various state and federal capacities, in particular, state agencies responsible for fish and game, the U. S. Fish and Wildlife Service, agricultural extension services in many states, and educational institutions. Students who have graduated in wildlife management are also available for employment by landowners to help manage their fish and game resources.

How can a farmer "sell" the hunting and fishing rights? For one thing, he can lease them to individuals or to a group of sportsmen. A local sportsmen's club might lease the rights and assume the responsibility of determining who gets a permit to hunt and fish and on what day. Some of these are open clubs that sell membership to all comers, up to the daily quota, at a price commensurate to the product provided. It is always attractive to the landowner when the sportsmen also patrol the area. Another method is for the owner to charge on an individual basis—first come, first served. This will bring in good revenue but requires more administration on his part. Or professionals can operate as middlemen, sharing in the landowner's profits by developing and selling access to the hunting and fishing resource and relieving the landowner of administrative responsibility.

The methods of managing hunting and fishing on private lands are probably as varied as the deeds of the lands concerned. Unfortunately, no one can either rightfully judge or adequately interpret the values someone else may place upon nature's wares. The value to different individuals of hunting and fishing exploits ranges from the satisfaction of spiritual needs to little or no reward for such ventures. One fisherman may find his satisfaction in physical exertion, whereas another may enjoy it most from a camp chair while floating his bobber in a not-too-responsive pool. But even though there is no set pattern of enjoyment, all have certain common desires. All sportsmen, as well as landowners, want restrictions that limit the number of people allowed access at any one time. Most don't want hand-reared targets, but they do expect a reasonable opportunity of having some success.

Sportsmen have demonstrated that they are not primarily after "meat," for they usually prefer to pay a flat fee for the access privilege rather than have the amount determined by what is actually in the bag or creel when they leave. The latter system does have appeal in some situations, though, for it serves as a guarantee that there will be plenty of game available, particularly where conditions are more artificial, as with the release of pen-reared birds or the maintenance of a rearing pond. Another important point is that some landowners have found that relief from trespass problems alone is worth the leasing of hunting and fishing rights.

A natural concern of landowners is how the sportsman, who may be total strangers, will behave after they acquire access rights. Obviously, the ability to shoot a gun or cast a lure does not by itself make one a sportsman. However, the code of sportsmanlike behavior is generally pretty well observed. Whenever access of sportsmen is controlled and the number allowed at any one time limited, their behavior has been excellent. In fact, property destruction and other abuses are usually less than they were when the land was posted and access "presumably" prohibited. Trespass problems on areas adjacent to places open by permit to sportsmen are also often greatly reduced.

Fortunately, for the most part, fish and game are a rapidly renewable resource. With conservative stewardship this is one time when the cake can be preserved and eaten too. Potentially, the wildlife legacy can provide beneficial recreation of the highest ethical value not only for the Izaak Waltons and Davy Crocketts of today, but for all their progeny as well. It is not blood lust or the enjoyment of taking life that makes sportsmen out of people—far from it. They are lured by the thrill of the adventure, by the excitement of hooking a fish, dropping a bird or stalking a deer, by the pleasure derived from anticipating such outings, and by the interminable post-mortems of those priceless experiences. Even though there is no one simple solution to the problem, the creation of an incentive among agriculturists, the principal landlord of farm fish and game, will certainly provide more opportunities for outdoorsmen as well as reduce the demands for further "opening up" of the few remaining wild areas.

DISCUSSION

CHAIRMAN PATTERSON: Thank you. I think that this is a very provoking subject and I am sure that there are many ideas on the way that private lands which probably now are closed to hunting can be operated for hunting.

I have a question or two with regard to this. I was wondering whether these areas that he is thinking about are waterfowl or upland game areas.

MR. LOSTETTER: I believe that they are upland game areas in particular. Of course, the paper suggested a remedy. I read an abstract of the paper but I do not know whether the remedy has been tried or not.

MR. BEN GLADING [California]: I think that we have tried about everything in California that has been tried elsewhere and some of these have worked and some have not.

One of the things that we have found in general is that it is very difficult to convince ranchers that they should take money on a daily hunt basis. They will lease their lands for upland game and bird hunting but generally to a restricted group and at a high price.

We have a program in California called the licensed game-bird club program, which is similar to the shooting preserve programs back East and there are quite a few acres of land that are leased to these private shooting preserves and to these licensed game-bird clubs at an extremely high rate. However, the ranchers in general have not accepted and do not seem to want to accept, under our present economic conditions, any daily-fee basis that the average sportsman can pay. Rather, we have found that the chief incentive that the ranchers want is protection and possibly some management. Of course, we have opened up a lot of areas of private land, but there again we don't work on a fee-to-the-rancher basis. In fact, whenever that has been tried the result has been so inadequate. What the owners want is protection and some element of game management fostered by the state. They do not seem to want to do it themselves even with a fee involved.

There is one interesting movement coming along in California along this line and that is the so-called community hunting area where the ranchers have gotten together by themselves with the object in mind of building a local swimming pool or fostering a local baseball club or building a park but then here again the chief incentive is one of protection.

MR. CRAWFORD [Missouri]: There is a question in my mind which the paper has pointed out and that is that probably the wildlife is already there and that it would not require any additional work on the farmer's part. I think that we feel tht if the private lands are opened up and commercialized that the population on those lands would not permit much hunting withotu a lot of additional work on the part of the farmer.

Now, are there any other states who might have had any related experience which we can throw into the hopper at this point?

MR. MOLLER [Idaho]: In our state we have organized what we call the sportsmens' land owner-land operator council. Of course, we have the same problems as you do elsewhere. However, our human population for the state as a whole is not high and so it is possible, under those conditions, to get key sportsmen and key land operators together on a committee basis. All that our department has done in this is to provide a meeting place and some stenographic help and keep a few records concerning the meetings. However, the sportsmen and land owners do get together on a committee basis through this council just to talk over these things that are always the same old problems.

I think that the important advances that we can make along this line are in the realm of human understanding and that is the approach this council takes. This has already been very productive.

MODERATOR CRAWFORD: Thank you. This is probably a question that has been discussed more than any question that we have in existence in the wildlife management field. I guess that everyone feels that a lot of things have been tried and that not too much good has come of it. However, the paper did suggest a remedy.

EFFECT OF LEGAL RESTRICTIONS AND HUNTING ON GRAY SQUIRREL POPULATIONS IN WEST VIRGINIA[1]

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J. M. Allen (1952) in his study of gray and fox squirrels in Indiana stated, "In large blocks of timber, it is doubtful if the hunters harvest a third of the summer population." His statement is in agreement with D. L. Allen's (1943) work on the fox squirrel in Michigan. Trippensee (1948), in summarizing the gray squirrel studies of Chapman in Ohio and Goodrum in Texas concluded that: "(1) hunting take is greatest during peak years . . ., (2) the percentage of kill at such times may be nearly half the population, and (3) areas protected against hunting are likely to support a larger population though not always."

Studies in West Virginia during the past several years indicate that underhunting rather than overhunting appears to be the problem in extensive forest lands. Two thirds of West Virginia's woodlands consist of extensive forests. The other third is in farm woodlots,

[1]A contribution of W. Va. P-R Project No. 31-R.

a large proportion of which are actually part of extensive forests since they lie adjacent to large tracts of woodland.

Game technicians checked a total of 20,271 squirrel hunters on state-controlled lands in West Virginia during the years 1948 through 1954. Information was gathered concerning hunting success and gun hours. A total of 17,535 squirrels were sexed and aged and 15,904 were weighed.

CENSUS METHODS

Squirrel populations on Seneca State Forest (10,670 acres) were estimated by time-area counts, leaf nest counts and hunting success during the first 1,000 gun hours.

Time-area counts. Time-area counts were run prior to hunting seasons in 1952, 1953, and 1954. Five men worked different forest types and stand sizes simultaneously. The counts were 30 minutes in duration and none was run after 10:00 a.m. due to decrease in squirrel activity. The area of the plot was obtained on the basis of a complete circle instead of three-fourths of a circle as suggested by Goodrum (1940). Based on the accumulative area sampled, the number of squirrels per 100 acres in each forest type was calculated daily. When the estimated number of squirrels per 100 acres showed a definite population trend and fluctuations ceased for several days in succession, censusing was discontinued when one per cent of each forest type had been covered. An exception was the red oak pole timber type, the acreage of which was too large to obtain a one per cent sample in the time allotted.

Leaf nest counts. A leaf nest survey was made in January and February of 1953. In 1953 and 1954 the survey was taken in late November and December after a study had indicated that leaf nest building ceased after the middle of November (Uhlig, unpublished). This study also showed that leaf nest building was closely correlated with spring and summer rearing success of juvenile squirrels. Leaf nest counts indicate that approximately 1.5 nests were built per juvenile squirrel. As a result, the following method was adopted in estimating the gray squirrel population density:

$$1.\quad \frac{\text{Leaf nests per 100 A.}}{1.5} = \text{Jv. squirrel per 100 A.}$$

$$2.\quad \frac{\text{Jv. sq. per 100 A.}}{\text{\% of jv. sq. in kill}} = \text{Total sq. density per 100 A.}$$

Totals of 400, 516 and 585 fifth-acre leaf nest plots were examined in 1952, 1953 and 1954, respectively.

Population estimates based on hunting success. On the hypothesis that a high density of squirrels would be expected to result in a high kill, the kill per 1,000 acres for the first 1,000 gun hours was used as an indicator of hunting success. This reduced variation due to fluctuations in number of hunters, individual gun hours, and increased wariness of squirrels as the season progressed. Friley (1955) stated, "The Rose Lake (Michigan) fox squirrel kill is considered to be quite reliable as an indicator of population trends."

It was found that 23 squirrels were killed per 1,000 acres, during the first 1,000 gun hours on Seneca State Forest in 1952 when the population density was estimated to be 43 squirrels per 100 acres. Application of this data resulted in the formula:

$$U = \frac{(43)\ (K)}{23} \text{ or } U = 1.87\ K$$

Where U equals the unknown density of squirrels per 100 acres and K equals the number of squirrels bagged per 1,000 acres during the first 1,000 gun hours.

Application of this formula to 1953 data resulted in a population estimate of 31.8 squirrels per 100 acres compared with estimates of 32.1 and 35.8 derived by the time-area counts and leaf nest counts, respectively.

Population estimates by all three methods were averaged and the final population was estimated to the nearest 100 squirrels (Table 1). During years of high populations, estimates by the hunting success method might be lower than the estimates derived by the other methods. This was apparent in 1954. It is particularly true if bag limits are sufficiently restricting.

TABLE 1. GRAY SQUIRREL POPULATION ESTIMATES BY THREE CENSUS METHODS, SENECA STATE FOREST, WEST VIRGINIA

Census Method	1952	1953	1954
Time-Area Counts	4,602	3,425	13,680
Hunter Success	4,588	3,393	9,500
Leaf Nest Counts	4,481	3,820	13,445
Average Population Estimates	4,557	3,546	12,541

According to the kill during the first 1,000 gun hours the 1954 population on Seneca State Forest was 89 squirrels per 100 acres or 9.500 for the total area (Table 1). The other methods provided estimates of 127 squirrels per 100 acres or 13,500 for the area. It is apparent that during high populations, hunters may report only the legal portion of their kill or some may obtain their kill early but report the same hunting time as their more unsuccessful companions.

The percentage of population bagged was 16 per cent by the hunter success method and 11 per cent by the other two methods. Some populations on other areas are therefore believed to be higher and the percentage of population killed lower. For moderate populations the formula is applicable to other forests in West Virginia where hunting records have been secured (Table 2).

Forest and Acreage	Year	Days Open	Hunter Success*	Est. Pop. Per 100 A.	Est. Pop. Total	Season Kill	% of Pop. Bagged	Gun Hours Per 100 A.
Cabwaylingo	1949	1	28	52	3400	256	8	22.9
	1950	7	23	43	2800	436	16	36.5
6,476 A	1951	10	53	99	6400+	833	13—	42.4
	1952	8	32	60	3900	581	15	49.1
	1953	43	54	101	6500+	646	10—	39.7
	1954	29	57	95	6200+	1265	20—	78.3
Kanawha	1949	2	25	47	3200	564	18	35.5
	1950	6	26	49	3400	834	25	83.2
6,843	1951	6	14	26	1800	378	21	53.3
	1952	4	24	45	3100	320	10	29.8
	1953	42	45	84	5700+	582	10—	45.2
	1954	29	42	79	5400+	1294	24—	104.2
Cooper's Rock	1949	30	15	28	3400	699	20	50.2
	1950	12	11	21	2600	369	14	25.3
	1951	16	24	45	3600	438	12	32.9
12,215 A.	1952	8	23	43	5300	566	11	22.4
Only 8,000	1953	42	16	30	3700	359	10	16.8
A. in 1951	1954	29	12	22	2700	366	14	23.2
Seneca	1949	2	79	141	9000+	479	5—	16.3
	1950	31	25	47	5000	857	17	33.1
10,671 A.	1951	19	32	60	6400	1141	18	36.2
Only 6,050	1952	8	23	43	4600	629	14	26.2
A. in 1949	1953	42	17	33	3500	169	5	8.9
	1954	29	48	117	12500	1522	12	50.7

*Number of squirrels killed per 1,000 acres during the first 1,000 gun hours.

EFFECT OF HUNTING

Population densities required for average hunting. A normal squirrel population and average hunting in West Virginia was evident when the take averaged one squirrel per hunter per trip. Apparently this was also true for Ohio (Chapman, 1941). In moderately hilly land approximately 47 squirrels per 100 acres were required to provide this level of hunting. On rougher terrain 55 to 60 squirrels per 100 acres were needed. Thirty squirrels per 100 acres resulted in poor hunting in all types of terrain. Whether populations were high or low, sight records and bag checks indicated that only about 37 per cent of squirrels seen were bagged. This is reasonably close to the 43 per cent derived in Ohio (Chapman, *op. cit.*) and the 38 per cent obtained in Indiana (J. M. Allen, *op. cit.*).

Proportion of the population taken by hunters. Estimates of populations on state forests and refuges, and records of annual take since 1949 indicate that an average of only 13 per cent of the squirrel population was killed by hunters. In 1954, during a peak in populations, the take was 19 per cent. In 1953, when the season was disrupted due to fire hazards, the take was only nine per cent. The kill in individual forests never went above 25 per cent of the total estimated population, far below Trippensee's (*op. cit.*) estimate of a 50 per cent take in peak years.

In spite of the relatively low proportion of the squirrel population taken, hunters found their hunting success diminishing after the fourth or fifth day of most seasons. It appeared that when approximately 10 per cent of a population had been killed, squirrels became more wary and were difficult to see or kill. In years of moderate or high populations and average or above average hunting pressure, this occurred during the first week. During years of low hunting pressure and low squirrel populations, hunter success during the last part of the season did not vary or decrease greatly from that experienced on the first day.

After the opening week, hunters generally saw more squirrels and killed more squirrels on days of heavy hunting pressure than on days when pressure was light. One possible explanation is that on days of heavy hunting pressure, hunters were forced back into the woods and away from the heavily hunted roadsides. During days of light pressure, when competition was not encountered, they were content to hunt near roads and foot trails in areas where squirrels had been previously heavily hunted.

EFFECT OF REGULATIONS

Season length. Many sportsmen are opposed to long seasons on the assumption that squirrels will be overhunted. Studies in West Virginia, where the squirrel is the number one game animal, showed that seasons over two weeks in length added little to total kill and yet provided additional recreation for those who were interested. Sixty-five to 75 per cent of the total kill were usually bagged during the first week. Only 3 per cent of all squirrels killed were taken during the fourth week of the season.

Since length of season is of relatively little importance, it is believed that the closing date should conform with the closing dates of other woodland species and, in the interest of public relations, should be of such length as to be psychologically acceptable to the majority of hunters after the facts have been repeatedly submitted to them.

Daily and seasonal bag limits. The daily bag limit has been four squirrels since 1937. A total of 20,271 hunters have been checked since 1948 and 7.2 per cent attained their legal bag limit. Table 3 shows that the percentage of unsuccessful hunters and hunters bagging one squirrel per trip varies little from year to year in spite of fluctuations in squirrel abundance. One exception occurred in 1948 when the sample of hunters was one-fourth or less of the sample obtained in other years. Regardless of hunting conditions, about one-half of all hunters fail to kill even one squirrel per hunt.

TABLE 3. SQUIRREL HUNTER SUCCESS SHOWING NUMBER OF HUNTERS CHECKED AND PERCENTAGE IN EACH CLASS OF SUCCESS

Year	No. of Hunters	Per cent of Hunters Killing 0 Sq.	1 Sq.	2 Sq.	3 Sq.	4 Sq.
1948	422	36.6	24.9	14.5	12.3	12.3
1949	2311	58.4	18.4	9.7	5.3	8.2
1950	4308	52.9	21.4	12.9	6.5	6.3
1951	4107	47.5	20.6	14.4	8.6	9.4
1952	3079	57.0	20.8	11.3	6.0	4.9
1953	1621	52.9	21.5	12.1	7.5	6.0
1954	4423	52.4	20.9	12.4	7.1	7.2
ALL YEARS	20,271	52.5	20.7	12.5	7.1	7.2

These data showed that the successful hunter (bagging at least one squirrel) averaged about two squirrels per effort. It is therefore doubtful that reduction of the daily bag limit in past years aided materially in protecting the squirrel population from overhunting.

While a bag limit might have the effect of distributing the less wary squirrels among more hunters, it is possible that a slight increase in the bag limit might aid in increasing the present inadequate harvest. Since the number of squirrels killed is self-regulatory, a slight increase would not be detrimental during years of low or moderate populations but would allow hunters to reap a better harvest during years of abundance.

A seasonal bag limit is practically non-enforceable and therefore does not merit discussion.

Opening date. Since the major portion of hunting pressure occurs during the first week, the season should be opened when the maximum population is available in order to obtain an adequate harvest. In West Virginia this is after October 15. Any earlier opening date would theoretically result in a decrease in the already inadequate harvest of the surplus. In four years out of five, the summer litter provides the larger proportion of juveniles killed. In an average year the majority of summer squirrels are not available to hunters until after October 15. Comparisons of data collected in 1953 and

1954 indicated that approximately 20 per cent more squirrels were available on October 15 than on October 1.

In 1954, when the season opened on October 1, it was estimated that at least 300,000 squirrels may have been lost due to shooting of lactating females that had young less than nine weeks old, and due to hunters discarding squirrels infested with bot fly larvae. An additional 400,000 juveniles whose mothers were killed were between nine and twelve weeks old. These squirrels would weigh less than 9.6 ounces around October 1.

Advocates of early seasons state that squirrels are more easily killed during the middle of September when they are "cutting" hickory. This opinion is popular in southwestern West Virginia adjacent to Ohio and Kentucky where earlier seasons prevail. While squirrels are possibly easier to kill when feeding on hickory in mid-September, the larger number available a month later certainly more than compensates for this slight advantage and makes squirrel hunting more sporting.

Increasing the annual harvest. As previously mentioned, the annual kill on all state forests studied during the past six years amounted to only 13 per cent of the population. The percentage of natural mortality is much greater, amounting to 56 per cent on Seneca State Forest and 44 per cent on Cabwaylingo State Forest when only 12 per cent and 17 per cent, respectively, of the population were taken by hunters. Undoubtedly a smaller natural mortality would occur on these areas if the harvest were increased. However, annual hold-over capacity and not hunter take is the most influential factor in total mortality. The necessity of increasing the hunter's harvest becomes quite clear when it is found that the natural mortality is three to four times as high as the hunter's take even though the hunter exerts an effort before the bulk of winter losses occur.

Because of the lessening of hunting pressure after the first week of the season and the limited number of hunters who attain daily bag limits, the problem of increasing harvests is a difficult one. The writer believes that an increase in length of season would raise the take about 2 per cent per week of increase. It is also estimated that an increase in daily bag limit by two squirrels would enlarge the total take about 5 per cent. Thus, with a three month season and a daily bag limit of six squirrels, the total take would possibly increase about 15 per cent. While this would appear to be a large increase, total increase in percentage of population taken would only amount to approximately two per cent on the basis that only 13 per cent of the population is now taken under the present regulations as they affect extensively forested lands.

Possibly the only way to increase the harvest in extensive forests would be to develop roads and well marked foot trails into areas where the average hunter is normally reluctant to venture.

SUMMARY

1. Application of three census methods: time-area counts, leaf nest counts and hunting success ratios gave similar and reasonable estimates of gray squirrel populations for three years on a 10,670 acre area.

2. In moderately hilly land 47 squirrels per 100 acres are required to provide an average kill of one squirrel per hunter per trip.

3. During years 1949 through 1954 only 13 per cent of the squirrel population was bagged on state-owned forests in West Virginia. The highest kill on any forest was only 25 per cent of the population.

4. Only 7 per cent of the 20,271 hunters attained their legal daily limit of four squirrels. Fifty-two per cent were unsuccessful.

5. Losses due to natural mortality appear to be three or four times that of hunter take.

6. It is difficult to increase the present inadequate harvest in extensive forest lands. Larger daily bag limits and longer seasons are recommended in addition to development of roads and foot trails.

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DISCUSSION

CHAIRMAN PATTERSON: I believe there is a growing interest in this country that present hunting regulations have relatively little effect upon game populations.

MODERATOR CRAWFORD: I would like to compliment this gentleman on the amount of information that he has gathered in connection with this paper. I thoroughly appreciate the amount of work involved in gathering this data. This type of work has been very popular over the past few years and I think that we are beginning to push back some of the unknowns in squirrel management. There has been a widespread amount of work done and this is another good example of study on a very important resource.

DR. R. E. TRIPPENSEE [University of Mass.]): I would question just one thing about the recommendations, that of taking off the seasonal limits, because that cannot be enforced. If he believes that the seasonal limit is correct then I believe that it should be left on even if it is not possible to enforce it, on the theory that most of our regulations, when you come right down to it, are suggestions. Probably 90 per cent of the sportsmen fellow the regulations not because they are forced to but because they believe in the regulations. Therefore, even though you canont enforce a thing I do not believe that it should be taken off.

MR. UHLIG: I might mention that I did not recommend that the seasonal bag limit be eliminated. I personally prefer a possession bag limit rather than a seasonal bag limit.

RUFFED GROUSE POPULATION STUDIES ON HUNTED AND UNHUNTED AREAS[1]

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In recent years, through work by Errington, Allen, and others, it has become increasingly apparent that levels of small game populations are governed by factors other than hunting pressure. Pheasant research (Allen, 1943; Shick, 1952) has shown that on very heavily hunted areas, a maximum of 75 to 90 per cent of the cock population may be harvested by the gun. Since the bulk of this crop is taken during the first few days of the season, Allen concludes a much longer season (more than 22 days in Michigan) would not result in a much heavier kill. Cock pheasants only, however, are legal targets in Michigan. Work on bobwhite (Baumgartner, 1944; Errington and Hamerstrom, 1935) and Gambel's quail (Swank and Gallizioli, 1954) has shown that on these species also, normal hunting pressure was not considered to be a factor responsible for abundance or scarcity. Studies on ruffed grouse in New York (Bump *et al.*, 1947) carried on in a small refuge and a hunted area showed similar populations during a three-year period, even though up to 20 per cent of the population was taken on the hunted area.

During the last population low in the Lake States of Minnesota, Wisconsin, and Michigan, four- and three-year closed seasons respectively in the two former states evidently did not create a higher population there, because when the season was again open in all three states in 1948 hunting success was similar (Ammann, 1949).

In Michigan, increased farmer-sportsman friction in southern Michigan pheasant range, better travel facilities, and a shorter work week for southern Michigan urban hunters has created a decided in-

[1]A contribution from Pittman-Robertson Project W-46-R, Game Division, Michigan Department of Conservation.

crease in grouse hunting interest. In the early forties only about 10 per cent of the small game hunters hunted grouse; in recent years nearly 20 per cent do (Palmer, 1953). We expect this trend to continue. Therefore, a study was begun in 1950 on two similar areas, one hunted and the other unhunted, to determine whether heavy hunting pressure on relatively small areas affected grouse population, and also to determine the percentage of the crop which could be safely harvested and what length season was required to do this. Detailed records of the kill on the hunted area were compared to population data obtained by various censuses during different periods of the year on both areas, to determine what effect hunting had on grouse numbers.

This study has been conducted through one phase of a cycle, beginning with a high population in 1950, through the low in 1954.

DESCRIPTION OF STUDY AREAS

Hunted area. The Rifle River Area comprises 4,318 state-owned acres in Ogemaw County, which is located in the northeastern portion of lower Michigan. Several lakes and beaver ponds, totaling about 450 acres, are sprinkled throughout the area. The Rifle River and several small tributaries run through it. Cover types present are typical of northern Michigan grouse range. About 50 per cent of the area is composed of upland aspen and aspen-hardwood type; 20 per cent is conifer swamp, consisting of white cedar, spruce and balsam; 15 per cent is upland openings and old farm clearings; and the remainder is northern swamp hardwood or mixed hardwood—conifer type. Many openings and sedge or willow-holly potholes are spread throughout these major cover types. "Edge" is therefore abundant, and if the area were properly managed, *i.e.*, the overpopulation of deer controlled, it would be difficult to select more ideal ruffed grouse habitat.

Hunting is permitted with no limit on numbers of hunters. All persons must enter and leave through a checking station, so details of their hunt can be recorded. Although some unauthorized hunting probably occurs, it is not considered to be significant. Hunting pressure is considerably heavier here than on similar blocks of land elsewhere in the state. Use of the area has increased steadily since its purchase in 1945. During this study an average of 800 hunters and 2,100 hours of effort were expended during the grouse season. This hunting pressure is roughly equivalent to one hunter spending 33 minutes hunting each acre. In comparison, our statewide data indicate that each acre supports about eight minutes of hunting.

Unhunted area. The Gladwin Refuge is located about 30 miles southwest of the Rifle River Area, in northwestern Gladwin County. This area is the site for several grouse dog field trials each year and the Grand National Grouse Dog Championship trial is held here once every three years. The 5,120 acres in the refuge contain the same type of habitat, with similar percentages in each type, as at Rifle River. These major cover types are less broken by potholes and small openings, however. Park-like conditions are present, presumably from heavy browsing by an overpopulation of deer.

Grouse hunting has been prohibited here since 1922, although some slight amount of violation may occur.

CENSUS METHODS

Four census methods were used: (1) strip census, (2) drumming cock counts, (3) analysis of hunting data, and (4) Lincoln index.

1. *The strip census method* (King, 1937) with the Hayne modification (Hayne, 1949) was used to obtain pre-season estimates in August and September, and post-season estimates in December. More than 2,000 miles of census lines were walked during the study. The limitations of these methods have been adequately described (Hayne, 1949; Robinette *et al.*, 1954; Palmer and Eberhardt, 1955) but a short statement here on data presented later is essential.

Strip census population estimates and standard errors are shown in Table 1. Some of the estimates have rather wide confidence limits. Larger samples would have been desirable in many of the censuses, but would have required much more effort than we could afford to expend at this time. While comparisons of the hunted and unhunted areas for single censuses may be uncertain, it seems evident that the summation of six year's data should provide quite a precise comparison.

2. *The drumming cock counts* in this study were made by locating

TABLE 1. GROUSE PER 100 ACRES ON HUNTED AND UNHUNTED AREAS[1]

	1950	1951	1952	1953	1954	1955	Ave.
Spring							
Hunted Area (Rifle River Area)		6.6	6.9	4.1	4.4	3.4	5.1
Unhunted Area (Gladwin Refuge)	6.9	6.6	5.9	8.4	3.4	3.1	5.5
Pre-season							
Hunted Area	28.1(3.8)	17.5(3.6)	16.2(3.1)	15.7(5.7)	7.5(2.8)	6.5(2.1)	15.3
Unhunted Area	24.8(3.3)	17.6(9.8)	9.2(4.1)	15.7(4.5)	1.9(1.3)	2.4(1.7)	11.9
Post-season							
Hunted Area	13.9(4.1)	7.0(1.4)	6.4(2.1)	5.9(2.8)	7.1(1.8)	3.2(0.7)	7.3
Unhunted Area	7.9(1.9)	5.1(1.5)	8.9(5.0)	4.1(2.9)	1.9(1.3)	1.5(0.8)	4.9

[1]One standard error is shown in parentheses after strip census estimates.

all drumming birds on a square-mile representative study unit in each area. Statistics reported herein on pre- and post-season populations and spring populations are therefore based on portions of each area rather than on the entire area, while kill data are from the entire hunted area. Hunting pressure per unit of land area on this study unit was equivalent to that received on the remainder of the entire area.

Drumming counts are considered to be our best census method. We believe that the similarity in spring populations of the two areas, as shown by drumming counts, provides considerable additional support for the thesis that hunting has little effect on subsequent fall populations.

3. *Daily hunting records* yield accurate production data per unit area. An attempt to estimate the pre-season population, and therefore the percentage of the population shot from daily kill records alone (DeLury, 1947) did not prove satisfactory. Success of this DeLury method depends upon the assumption that vulnerability to hunting remains constant throughout the season. Leaf-fall, however, appears to have a decided effect on grouse vulnerability. The daily kill records show a surprisingly high kill on opening day, regardless of heavy foliage, followed by a general downward trend in hunting success. Following leaf-fall an increase in success is apparent to the end of the season. As many grouse hunters are aware, late-season hunting is often more productive than early-season hunting.

Even though we have not been successful in using the kill data to compute pre-season populations, it seems remarkable that with a season kill approaching 40 per cent of the population, numbers of grouse are still taken late in the season.

4. Use of the *Lincoln index* has been possible the last year of the study only, when a large enough percentage of the population was banded.

Tables 1 and 2 summarize the data obtained in this study, and Figure 1 graphically presents the populations throughout the year

TABLE 2. RECORDED KILL, PER CENT HARVEST AND PERCENTAGE OF PREVIOUS FALL POPULATION REMAINING TO SPRING ON HUNTED AND UNHUNTED AREAS[1]

	1950	1951	1952	1953	1954	1955	Ave.
Kill	5.1[2] (18)	3.8 (22)	8.5 (52)	4.9 (31)	2.0 (27)	2.8 (43)	4.5 (32)
Per cent of Population Remaining Following Spring:							
Hunted Area		23	39	25	28	45	
Unhunted Area		27	34	—[3]	22	—[3]	

[1]Populations expressed as grouse per 100 acres.
[2]Figures in parentheses represent per cent of population shot.
[3]Spring population larger than previous fall population.

on the two areas. From these tables and graph, the following conclusions appear warranted:

RESULTS

Spring populations on the two areas have been comparable. Since spring drumming counts are for males only, we assume a balanced sex ratio to obtain the spring population. The range of spring populations on these study areas was from 3.1 to 8.4 grouse per 100 acres, with the present low population being about one-half that of the high. The average spring population on the unhunted area was slightly higher than on the hunted area, although the difference is not significant.

Pre-season populations on the two areas have been comparable. In 1950 both areas had populations between 25 and 30 grouse per 100 acres. A close inspection of Table 1 reveals that on the hunted area there has been no "crash" in population, but a gradual decline in abundance since the high of 1950. On the unhunted refuge, however, a crash apparently did occur in the winter of 1953-54. A sudden decline in spring population and an apparent lack of production the following summer resulted in a very poor population in the fall of 1954.

The kill on the hunted area has averaged 4.5 grouse per hundred acres. The average mean pre-season and post-season population has been higher at Rifle River than at the Refuge, even though the spring populations have been slightly smaller. In years of high populations and a long hunting season (1952) nearly 10 grouse per 100 acres were shot.

The kill on the hunted area has averaged about one-third the pre-season population. It should be pointed out, however, that this is the actual recorded kill, and crippling losses are not considered. The effect of removing about 50 per cent of the population in 1952 will be discussed later.

The percentage of the previous fall population present the following spring has been similar on both study areas. Roughly one-third of the population present in the fall remains in the spring regardless of whether birds have been removed by hunting or not.

Prior to 1952, the Michigan grouse season was 22 days. In 1952 the season was almost doubled, to 41 days. Although specific information on the percentage of the population shot in a 22-day season was lacking, the Minnesota-Wisconsin-Michigan comparison certainly was justification for a longer season, at least during a high. With a 22-day season, the Rifle River kill averaged about 20 per cent. Since

1952, the kill has averaged almost 40 per cent. Indications are (Table 1) that the large kill in 1952 reduced the subsequent spring population somewhat. However, the fall population in 1953 on the hunted area was almost identical with that of the unhunted area. Therefore a kill of 50 per cent had no effect, as nearly as we can tell, on the following *fall* population. In fact, this heavy kill in 1952 may be one reason there was no crash such as occurred on the unhunted area the following fall (1954).

From the data it appears that a season designed to remove 40 per cent of the population is certainly justifiable. In Michigan, considering state-wide hunting pressure, the season could possibly be lengthened to two or even three months to obtain this kill.

LIVE-TRAPPING STUDY

Using live-trapping techniques described by English, Bailey, and Low, and modified by Dorney and Mattison (1956) a total of 102 grouse was banded on the hunted area prior to the 1955 hunting season. Fourteen of these birds were spring-trapped cocks and the remainder were trapped during September. Returns were received on 17 of these birds. Movements of grouse, with the exception of adult cocks, are considerably greater than previously thought. With one exception, adult cocks were shot on or very close to the trapping site. The rest of the birds, as can be seen in Figure 2, were quite mobile. In fact, one grouse was recaptured over one-half mile from the release site of the previous day. This bird was subsequently shot almost a mile from the second release site. Grouse apparently will move considerable distances—perhaps several miles as juveniles (Dorney, 1954). However, apparently once adult cocks establish a territory they are inclined to stay put.

Lincoln Index. Use of the Lincoln index showed a pre-season population of 17 grouse per 100 acres. A possible bias seems apparent, however, from an examination of Figure 2. Movement data obtained from hunting recovery of banded birds indicates that a substantial portion of the banded birds may not have been subject to Rifle River hunting. Even though local people were informed that banded grouse were present in the area, no bands were returned from outside the Area. It is concluded therefore that any study designed to obtain population data from use of the Lincoln index should be done on an area considerably larger than the Rifle River Area. Such an area should probably be at least 10,000 acres in size—or an island.

SUMMARY

During a six-year period representing a cyclic phase from a high population to a low, studies on a heavily hunted area and on an

unhunted area showed that removing an average of 40 per cent of the population by hunting had no apparent detrimental effect on the subsequent fall population. Since the relatively small hunted area received about four times as much hunting pressure as the state average and was not overharvested even during a 41-day season we conclude that Michigan could probably have a two- or three-month, or possibly even longer grouse hunting season.

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DISCUSSION

MODERATOR CRAWFORD: It looks as though the interesting thing here is that we have suspected a lot of these things over the years but that now we are getting the facts and figures on them. Therefore it looks as though a real contribution has been made here.

MR. UHLIG: I was interested in the point brought out by the graph in that you have the same spring population level throughout all the years. I think that was also shown by the New York study and, interestingly enough, on my squirrel study we found that the entire population also went down to that level. Several years ago West Virginia extended the season from seven and a half weeks to two months and we have not seen any detrimental effects on the grouse population.

MR. PALMER: I think that I would say that the current spring population is roughly one-half of the spring population during the high, although perhaps in that graph this is not shown too clearly.

MR. FRYE [Florida]: I note that you said that your kill went out when you increased your season. Why was that—because of the increased interest due to the more liberal season?

MR. PALMER: That is probably due to several things. In Michigan, since 1952, the grouse season opens in the north before the pheasant season in the South and so you get an influx of downstate hunters, who apparently do not bother with grouse when pheasants are legal. Also the area has received a good deal of publicity and the interest in it has gone up since its purchase in 1945.

MR. EARL FRYE [Florida]: What difficulty did you have when you increased that season? In the south we have a great deal of objection to any liberalization of seasons. Do you have any difficulty with your grouse season in that respect?

MR. PALMER: Yes, I think that we are about two years behind time on that. Prior to 1952 we had a season of 22 days. We could shorten it but not increase it. We now have it up to a maximum of 41 days. Even though it took a long time to get that through I don't think that we are having any trouble. We have not had any reaction.

MR. FRYE: That graph could certainly be misinterpreted if someone wanted to use it.

MR. PALMER: Yes, it could. I would say that it is a generalization.

MODERATOR CRAWFORD: There is a tendency on the part of the states to destrict the season because they feel that a short season is successful. However, I don't think that we are giving enough of an opportunity to persons who want to maek trips into the field for the purpose of enjoying the sport.

DR. JOSEPH HICKEY [Wisconsin]: I wonder if Mr. Palmer would tell us what the place of crippling losses is in this 40 per cent of permissible take?

MR. PALMER: That is a point that I forgot to mention. We do not have any information on crippling loss. We tried a couple of years ago to question hunters with regard to this but we found that they were reluctant to state whether they had killed or crippled any birds and then not found them for any reason. This would be our only way of getting that figure.

Further, where the populations are higher we also seem to get a higher kill.

AN ANALYSIS OF TECHNIQUES FOR DETERMINING MALE SQUIRREL REPRODUCTIVE DEVELOPMENT[1]

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Knowledge of breeding cycle dynamics and age composition is desirable for the effective management of a game population. Tree squirrels (*Sciurus*) are an important game resource as shown by the annual kill ranging from a half to several million animals in each of several states within their range. Squirrel management which is probably limited to manipulation of season length and bag limits should be influenced by the best available knowledge concerning the breeding status and the reproductive potential.

Following the classic works of Allen (1942, 1943) and Brown and Yeager (1945), a number of states have reported squirrel studies, most of them emphasizing reproduction aspects while using field examination techniques and perpetuating the vocabulary used by the earlier workers. As criteria of sexual development and age in males, attention has been centered on the appearance of external genitalia and measurements of the testes and Cowper's glands. Many references may be found to "juveniles," "yearlings," "adults," "breeding condition," "non-breeding males," "sexually high," etc., such classifications of age and sexual development being based upon subjective estimations.

Live trapping records (Allen, 1942) as well as post-mortem measurements (Brown and Yeager, 1945) gave good evidence that the swelling of testes and Cowper's glands is followed by shrinkage, and that this sequence is repeated as the adult male experiences successive periods of rut and sexual dormancy. Thus, adulthood is a questionable indication of sexual potency in male squirrels since those in the ebb of the sexual cycle would be incapable of breeding for lack of sperm or essential secretions. The span of an individual inactive period is unknown; but more basically, the relationship between testis and Cowper's gland size and the beginning of either the non-functional or functional state cannot be determined by external examination. In addition to the cycling adults most populations contain juvenile males showing prepubertal gains in testis size and turgidity further complicating the picture with gross characteristics resembling those of transitional adults.

Brown and Yeager (1945) stated that, "enlarged testes and Cowper's glands are obvious indications of breeding condition." If the

[1]Journal Paper No. 954 from Purdue University Agricultural Experiment Station in cooperation with the Indiana Department of Conservation.

term "breeding condition," as used variously by these and other authors, means the ability of the male to impregnate the female, the fallacy of correlating swollen glands with such potency is apparent. The potency of the male squirrel probably requires the active role of other glands including the well developed prostate and seminal vesicles (both internal) as well as the essential production of sperm and their storage in the epididymis. Since these portions of the reproductive system and their functional condition are not apparent externally, the reliability of assigning breeding status or age to full-sized squirrels on the basis of genital size is definitely limited. The microscopic examination of reproductive organs, particularly the testis with respect to the production of sperm, seemed to offer a more accurate means of determining breeding status or sexual development, the latter of which we believe to be a better term. However, histological studies of the squirrel testis (Kirkpatrick, 1955) and accessory glands (Hoffman, 1952; Mossman *et al.*, 1955) revealed that neither testis nor accessory gland histology is infallible in determining sexual development, or even age, but that a combination of both is needed. In the works just cited and in the present paper, we have regarded the two important age classes as being determined by sexual development. As shown by histology of the reproductive system, the adult male has attained full sexual capacity for breeding while the juvenile has not. The sexual development groups which comprise these two age classes have been described in detail (Kirkpatrick, 1955; Mossman *et al.*, 1955) and are summarized here:

1. The *infantile* in which the testis has closely-packed seminiferous tubules, of small diameter without natural openings, and usually bounded by thin connective tissue membranes. The accessory glands are small and show no evidence of cellular enlargement or secretory activity.
2. The *prepubertal* in which the first signs of luminal openings show in the seminiferous tubules, but prior to actual sperm production. Prepubertal accessory glands include those showing any secretory activity up to abundant secretion of the fully functional stage.
3. The *functional* stage when the testis contains free sperm or sperm head bundles and shows no evidence of recent or impending degeneration to the inactive stage. The accessories have high secretory epithelium and an abundant storage of secretion.
4. The *degenerating* stage when the testis shows evidence of being non-functional, ranging from the first signs of general disorganization and sloughing of the germ layers to the final point when the tubules appear similar to those of infantiles. In late degeneration, the basement membranes bounding the tubules are typically thick

and heavy. In early degeneration of the testis, the accessory glands may appear functional and thus lead to error in classification if they are used alone. In late degeneration, however, the connective tissue of the accessory glands, particularly the Cowper's gland, increases in mass and density, becoming less cellular and more fibrous, thus providing a clue for differentiation when the testis approximates the infantile condition.

5. In the *redeveloping* adult, the first testis change is a slight enlargement of tubules as the solid centers open to form new lumina. At this time they may be confused with the prepubertal condition. However, the accessory glands during this second period of enlargement apparently are not as sensitive to stimulation as during the first period and frequently remain in the degenerative condition even up to the point of sperm production. Thus with the accessory glands available, the redeveloping stage can be distinguished from the prepubertal and early functional stages.

With this knowledge of the cyclic histological changes occurring in the male squirrel reproductive organs, it was decided: 1) to compare palpation impressions of Cowper's gland with the developmental classes for the purpose of determining accuracy of using Cowper's gland gross size in assigning age or sexual development; 2) to determine the reliability of testis histology as compared with accessory gland histology in determining sexual development, using the combination of the two as the final criterion; and 3) to establish the range and variation in reproductive organ size in each of the developmental stages.

MATERIALS AND METHODS

The materials consist of tissues, measurements, and observations from male fox squirrels (*Sciurus niger rufiventer*) and gray squirrels (*S. carolinensis*) comprising a total of about 540 animals handled, divided about evenly between the two species. Of this number, 131 were from Wisconsin, collected by Dr. H. W. Mossman from 1927–38, and the remainder were collected in Indiana from 1946–54. Most animals were shot or live trapped with a very few salvaged as road kills. Due to changing objectives, post-mortem collection of data and tissues was not standardized, particularly with respect to the parts included from the Indiana squirrels, until about 150 Indiana males had been collected. Therefore, not all specimens contributed the same volume of information although the methods used were consistent after a procedure had been adopted. For example, in the initial phases of the study, only the testes were measured and saved for histological study and the Cowper's glands were palpated externally and subjective impressions of their size were recorded. (Thus in the first phase of this study, the five stages of development are based upon testis histology alone.) Upon discovery (Hoffman, 1952) that testis histology often does not furnish an accurate diagnosis, all reproductive organs were saved and studied in the aggregate for determining the development in subsequent specimens.

The testes were removed from the scrotum, freed of epididymides and measured to the nearest millimeter along length and width. After external palpation, the impression of Cowper's gland size was recorded and the glands were then removed and measured across the greatest diameter perpendicular to the exit of the duct. All tissues were preserved either in Bouin's or A.F.A. (alcohol-formol-acetic acid) fixative, embedded in paraffin and sectioned at 6 to 10 micra. Staining was with Harris' hematoxylin in combination with eosin or phloxine or with Biebrich scarlet and fast green.

RESULTS AND DISCUSSION

The first 52 squirrels which were collected over a 3-month period were classified as juveniles or adults by the external examination of genitalia according to the criteria of Brown and Yeager (1945). When the testis sections were studied, no less than 12 mistakes (23 per cent) had been made by the external method. Some of the supposed juvenile testes contained sperm, while some classified as adults were only maturing juveniles. Again, some adults, considered as obviously "in breeding condition" were found to be degenerating (Figure 1). Such errors in separating juveniles from adults and breeding from non-breeding males result from a confusing intergradation in size and weight of sex glands between ages and sexual development groups. While a large number of pictures would be required to show the full range of overlap in appearance of external genitalia, Tables 1 and 4 show the extensive intergradation of testis and Cowper's gland measurements which are reflected externally.

TABLE 1. INTERGRADATION OF TESTIS WEIGHTS AMONG SEXUAL DEVELOPMENT CLASSES (FOX SQUIRRELS)

Sexual development	Number of animals	Range of testis weights (grams)
Infantile	12	0.1 - 0.8
Prepubertal	20	0.4 - 3.2
Functional	37	2.6 - 12.6
Degenerating	20	0.7 - 10.4
Redeveloping	6	1.7 - 5.5

This cursory survey and comparison between gross and microscopic examinations of the same animals immediately raised the question whether any male squirrel could be classified with certainty as to age or sexual development by the external method.

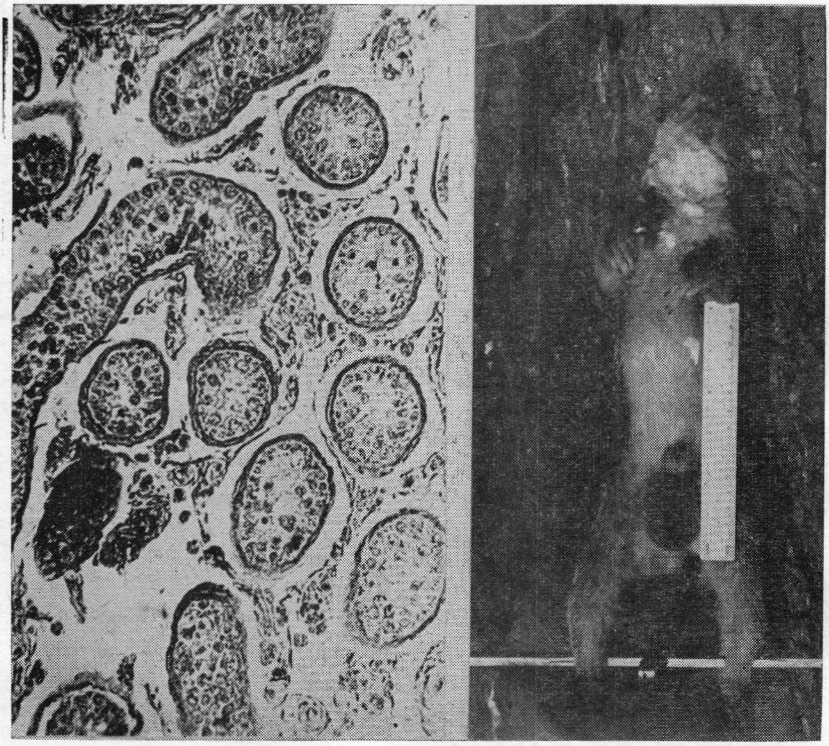

Figure 1. Fox squirrel taken October 1 with extremely large testes (10.4 grams) and Cowper's glands. On the basis of genitalia size and appearance, this male would be classified as "in breeding condition," but the specimen is actually in senile degeneration as shown by the testis section (right). The shrunken seminiferous tubules containing only primitive germ cells and completely disorganized interstitial tissue cells characterize the advanced degeneration stake. The epididymis was not saved from this specimen, but others with testes in similar condition have epididymdes free of sperm.

Another series of squirrels was used for the purpose of comparing sexual development, as determined by testis histology, with gross Cowper's gland size based upon palpation impressions. At autopsy, the size of the Cowper's glands, as felt beneath the finger tips through the skin, was recorded in three broad groups as follows:

A. Very small; not or barely palpable. In this stage, the prominent pubic bones form with the root of the tail a cavity containing the gland, which, if detectable, is difficult to hold for continued palpation.

B. Beginning enlargement and easily palpable. Slipping beneath the fingers is reduced as the gland seems firmly attached to the fascia, but it does not project much if any beyond the ischium, and it is not visible as a swelling.

C. Well developed; large to very large. The gland is greatly swollen and easily seen projecting as much as 20 millimeters beyond the ischial tuberosity.

Ninety-five fox squirrels were handled, and classified into the three groups above by means of gross Cowper's gland impression, and their testes were examined microscopically with the results shown in Table 2. This reveals the measure of overlapping found in ages and stages of sexual development when Cowper's gland size is used as a criterion for either. Thus groups A and B do not even serve to distinguish juveniles from adults while group C designates adults with certainty but gives no clue to the stage of sexual development. Other data (Kirkpatrick, 1955; Mossman *et al.* 1955; and Table 4) indicate that Cowper's glands of more than 8 millimeters in flat diameter are from adults, but smaller Cowper's glands are indeterminate. It is concluded that palpation or measurement of the Cowper's gland is a poor cri-

TABLE 2. AGE AND STAGE OF SEXUAL DEVELOPMENT ACCORDING TO TESTIS HISTOLOGY AS COMPARED WITH COWPER'S GLAND SIZE IMPRESSION'S[1] (FOX SQUIRRELS)

Cowper's gland size impressions

Age and stage of sexual development	A Very small; not or barely palpable	B Beginning enlargement; easily palpable	C Well developed; large to very large
Juvenile			
Infantile	12		
Prepubertal	13	2	
Adults			
Functional	9	5	28
Degenerating	5	5	9
Redeveloping	4	3	
Total	43	15	37

[1]When the Cowper's glands in 38 of these squirrels were dissected out and their flat diameters measured at a point perpendicular to the duct exit, groups A, B, and C ranged from 2-4, 6-14, 13-20 millimeters, respectively.

terion for determining sexual development, and has only limited application in aging male squirrels.

As previously stated, testis histology alone does not always indicate the sexual development for several reasons, one being the difficulty of separating prepubertal and redeveloping males. Both have enlarging seminiferous tubules and newly opening lumina. Hoffman (1952) and Mossman *et al.* (1955) reported that cellular development and secretory activity in the accessory glands are not synchronous with testis activity, and that this asynchrony can provide in some cases the diagnostic clue to the actual stage of sexual development. For example, the seminal vesicles of young males may show beginning epithelial activity and increasing lumina size indicating the prepubertal male before any changes are apparent in the testis. Again, the Cowper's gland is often secreting, *i.e.,* functional, and sperm are occasionally present in the epididymis after the testis has shown definite signs of early degeneration. In late degeneration, however, the Cowper's glands are invested with heavy connective tissue characteristic of the degenerate (resting) condition, at a time when the testis can be confused with the infantile. As the testis redevelops, the accessory glands frequently lag well behind and may remain in the degenerate condition up to the point of sperm production. By the characteristic appearance of the degenerate Cowper's gland, a ready distinction between the redeveloping versus the prepubertal and functional animal is afforded.

To determine the percentage accuracy in using testis histology as the criterion of sexual development, a group of males already classified by testis histology was reclassified by accessory gland (mainly Cowper's gland) histology without reference to the testis. An inherent error of equal magnitude was soon apparent, however, in use of accessory gland histology without reference to the testis, so a corrected classification was ultimately devised using all available organs and taking into consideration the variations described above. This final analysis is believed to represent the highest degree of accuracy within the limits of individual interpretation and thus evaluates the accuracy of determining sexual development by testis sections alone (Table 3).

TABLE 3. ACCURACY OF TESTIS HISTOLOGY AS A CRITERION OF SEXUAL DEVELOPMENT

Stage of sexual development						
Based on *testis* only		Based on *accessory glands* only		Based on testis *and* accessory glands		Percentage accuracy using testis only
24	Infantile	21	Infantile	21	Infantile	87.5
		3	Prepubertal	3	Prepubertal	
15	Prepubertal	2	Infantile			
		8	Prepubertal	12	Prepubertal	
		2	Functional			80.0
		3	Redeveloping	3	Redeveloping	
106	Functional	10	Prepubertal	10	Prepubertal	77.3
		82	Functional	82	Functional	
		14	Redeveloping	14	Redeveloping	
14	Degenerating	1	Infantile	1	Infantile	92.9
		2	Functional			
		11	Degenerating	13	Degenerating	
16	Redeveloping	1	Infantile	1	Prepubertal	93.3
		2	Functional			
		13	Redeveloping	15	Redeveloping	
175	Total				Average	86.2

As an example of the reasoning involved in establishing the corrected classification (Table 3), consider the prepubertal group. Of 15 animals classified as prepubertal on the basis of testis histology, only eight were prepubertal by accessory gland interpretation, while two were classified as infantile (no development), two as functional (high epithelium and secretion present) and three as redeveloping. However, since all 15 animals showed seminiferous tubule enlargement and lumina formation in the testis, the two classed as infantiles because of inactive accessory glands must necessarily be placed in the prepubertal group. The fact that no sperm were found in any of the fifteen precludes the possibility of truly functional animals regardless of the condition of the accessory glands. The reclassification of the three as redeveloping is without doubt correct considering the Cowper's gland histology as an accurate indicator of this group as explained above.

Summarizing Table 3, the use of testis sections alone gives reliable results in approximately 86 per cent of the cases, and accessory gland histology alone is accurate in about 88 per cent of the cases. It will be noted that errors in judgment with testis alone are of three main categories:

1. The occasional early prepubertal animal showing no discernible testis development but beginning accessory gland development is erroneously classified as an infantile.
2. The tendency to mistake the presence of sperm as an indicator of functional activity when the accessory glands are not functional.
3. The tendency to confuse the testis of early redeveloping males and prepubertal males.

It is apparent that a combination of both testis and accessory gland histology is required for completely reliable determinations of sexual development.

In the matter of determining age, *i.e.*, separating juvenile from adult squirrels, the use of testis sections alone will give 89 per cent accuracy which compares favorably with the 77 per cent arrived at by using the external method on the 52 test squirrels mentioned above.

The final phase of this study was to determine whether any reproductive gland measurements would furnish clues to the age and sexual development of male squirrels. Testes and Cowper's glands were measured as previously described in a total of 189 animals which were later classified into the five categories using both testis and accessory gland histology. In both the testis and Cowper's gland measurements, a wide range in size is apparent within each class with excessive overlap occurring between classes. This is true for both species (Table 4). With these data, only a few positive statements are permissible. For example, in the fox squirrel, any testis measuring under 9 by 4 millimeters is from an infantile animal. A testis over 24 by 11 millimeters or a Cowper's gland over 8 millimeters designates an adult, but by its size neither organ can reveal whether the adult is in the functional, degenerating, or redeveloping stage.

TABLE 4. RANGE IN TESTIS AND COWPER'S GLAND SIZE IN RELATION TO AGE AND STAGES OF SEXUAL DEVELOPMENT
(Based on Accessory Gland *and* Testis Histology)

Age and stage of sexual development		Range in size (millimeters) No.	Testis	No.	Cowper's gland
			Fox Squirrels		
Juvenile					
	Infantile	7	8 by 3 — 15 by 6	7	2
	Prepubertal	14	9 by 4 — 24 by 11	12	2 — 6
Adult					
	Functional	34	22 by 14 — 34 by 15	30	5 — 20
	Degenerating	4	12 by 7 — 22 by 13	4	3 — 15
	Redeveloping	9	16 by 6 — 29 by 14	9	5 — 8
	Total	68		62	
			Gray Squirrels		
Juvenile					
	Infantile	18	7 by 4 — 13 by 5	18	2 — 4
	Prepubertal	7	9 by 4 — 21 by 11	9	2 — 8
Adult					
	Functional	37	19 by 11 — 30 by 15	48	5 — 16
	Degenerating	9	10 by 5 — 23 by 12	9	3 — 9
	Redeveloping	16	13 by 7 — 24 by 13	19	4 — 9
	Total	87		103	

In the majority of male squirrels, the testes and Cowper's glands fall into the intermediate, overlapping size classes and give no reliable clues even to age.

From these studies it is clear that subjective impressions or lineal measurements of male squirrel reproductive glands are inadequate for determining sexual development, and organ weights have also been shown to be invalid (Hoffman, 1952; Kirkpatrick, 1955; and Table 1 of this paper). As a practical consideration, the present studies further indicate the risk of separating the male squirrel kill even into age classes by the routine check of external genitalia or sex organ dimensions.

Conclusions drawn from this study may prove useful for the future studies of other seasonal breeders and stimulate additional objective observations of this type to aid in determination of age and sexual development.

SUMMARY

An analysis of the commonly employed field techniques for judging sexual development and age in male squirrels was made using histological examination of reproductive organs. It was found that general appearance of external genitalia, grouping by Cowper's gland palpation, or measurements of reproductive glands are poor criteria for determining sexual development, and are not reliable for separating adults from juveniles. Histological analysis of the testis alone is accurate about 86 per cent of the time for determining the stage of sexual development, but a similar analysis of the accessory glands in combination with the testis is necessary for the highest degree of accuracy.

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DISCUSSION

MR. CRAWFORD: This paper is a good example as to what is happening in our field. In the earlier days much of our work was conducted by cross-examinations of animals and it seems that we are now again evaluating our earlier techniques. I think that this is a good indication of what is happening in our profession.

Now, the question that I would like to pose with regard to this technique is—what chance do we have of making such a technique available for the wide examination of animals? I don't think you referred too much as to the time involved, the expense and so on.

MR. HOFFMAN: This is not adapted as a field technique. It is more a check on the routinely applied techniques and I would not advocate it as a normal field technique. However, if a sample is required it could very well be used, providing the laboratory facilities are available.

ANALYSIS OF MARTEN EXPLOITATION AS CRITERIA OF MANAGEMENT

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The exploitation of animal populations has been studied by several Russian biologists (Formozov, 1941), (Naumov, 1938), (Strogonov, 1941) but not much has been done on this subject in America. In order to analyze exploitation it is desirable to have a census as a basis for evaluating its effects on the population, such as in livestock management. Generally, only kill records are available to represent the level of utilization[1] of game. These would provide a basis for analysis if they constituted an adequate sample of the population. Kill records are frequently inadequate for the purpose of describing population characteristics or providing management criteria; but sometimes enough can be learned from an analysis of kill records to permit administration of game resources on a biological basis.

[1]Exploitation and utilization are used herein as synonyms.

The results of marten (*Martes americana*) trapping have been described in several ways by Marshall (1942), Yeager (1950) and Quick (1953). More recent investigations of existing marten populations (Newby, 1954) have been very helpful as a means of interpreting the results of trapping. Newby's work has exposed some errors in previous analyses of the catch records of marten.

Studies of fur resource use in northern British Columbia[2] revealed several criteria that could be used to regulate utilization. An analysis of the exploitation of a marten population (Quick, 1956) forms the basis of the present paper. Exploitation has been described by comparing the sex and age class characteristics of trapped samples to hypothetical population structures calculated from reproduction characteristics; and by comparing the sex and age class characteristics of segregated samples from different traplines. The comparisons were interpreted in terms of "trapping pressure," that is, the timing of trapping and the spacing of traps.

Two hypotheses were demonstrated by this analysis. (1) In the exploitation of marten the sex ratio of the kill varies with the application of trapping pressure. This is caused by the relative spatial distribution of the sexes in relation to the time factor in "trapping pressure" rather than from an unbalanced sex ratio as was previously supposed (Grinnell, *et al.*, 1937). Variation of sex ratio in the kill has been more fully described in a previous paper (Quick, 1956) but can be schematically demonstrated as in Figure 1 where the sex ratio of the catch is illustrated in relation to the timing of trapping pressure. Both males and females were taken during the first month of trapping. However, the collections showed that three or four males per female were taken during the first part of the season. During the second month the cumulative ratio was reduced to roughly two to one. Pressure continued through the third month resulted in an even sex ratio of the catch. Further exploitation tended to collect males and females indiscriminately with no significant variation in proportions. The diagram illustrates that it takes longer to attain a given level of exploitation of the female segment of the population than of the male segment. This agrees with the results of live trapping obtained by Newby in Montana. As trapping pressure in the time-sense is continued the catch of males falls off, but the catch of females continues until approximately equal numbers are taken. Trappers are conscious of variations in the proportion of male and female marten in their catches and their opinions differ concerning the significance of these results. When they observe a high ratio of males

[2]Project ONR 6, Arctic Institute of North America, Wildlife Management Institute and National Wildlife Federation, unpublished manuscript, 1950.

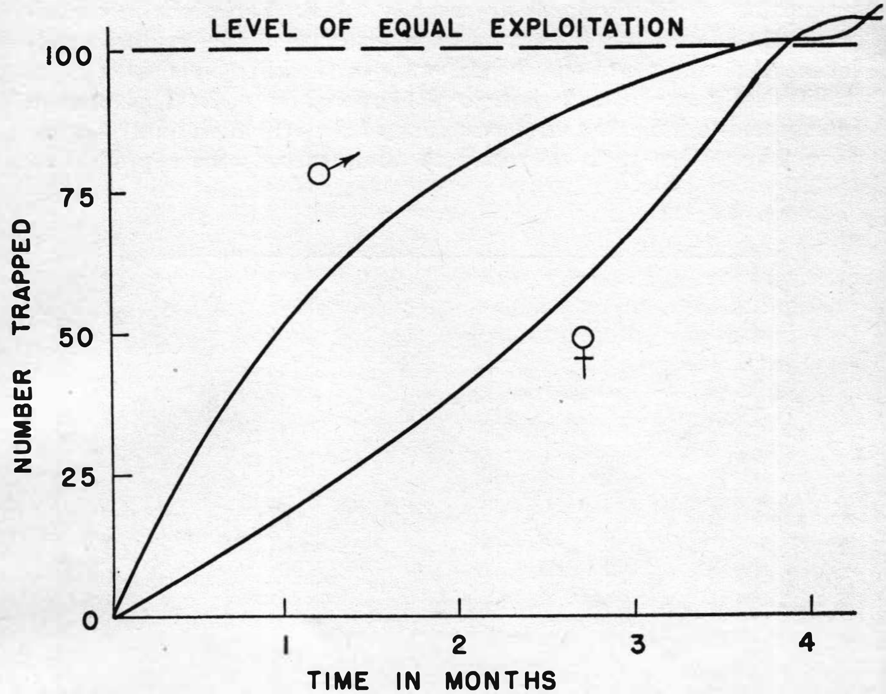

Figure 1: Effects of trapping pressure on sex ratio of the kill.

in fur collections, they generally believe that previous trapping has been too severe and has not left enough females to perpetuate the species. If trapping is curtailed, the trappers never learn what continued trapping pressure would produce; nor do they realize that the residual population might consist largely of females.

(2) Another hypothesis of exploitation is that the age structure of the kill, and also of the residual population, varies with the current and previous level of exploitation. A comparison of the age class structures of segregated samples (from different areas or different trap lines) revealed that intermittent and continual trapping pressure resulted in kills with different age structures. Where exhaustive trapping pressure had been applied continually in previous seasons there was a tendency for more animals of the younger age classes to be taken because of the immigration of young animals into a vacuum created by perennial exploitation. Under such conditions the younger age classes in the exploited area are usually numerically superior to older age classes and are therefore more likely to be caught. In areas where exploitation has been below the level of recruitment a larger

proportion of older animals are usually taken. Variations in exploitation therefore alters the sex and age structure of the residual population. An example of the age structure of the kill (females only) in an intensely exploited region is shown in Figure 2. This can be interpreted to indicate that more young of the year than adult marten were taken. The ratio of young to adult exceeds the reproductive

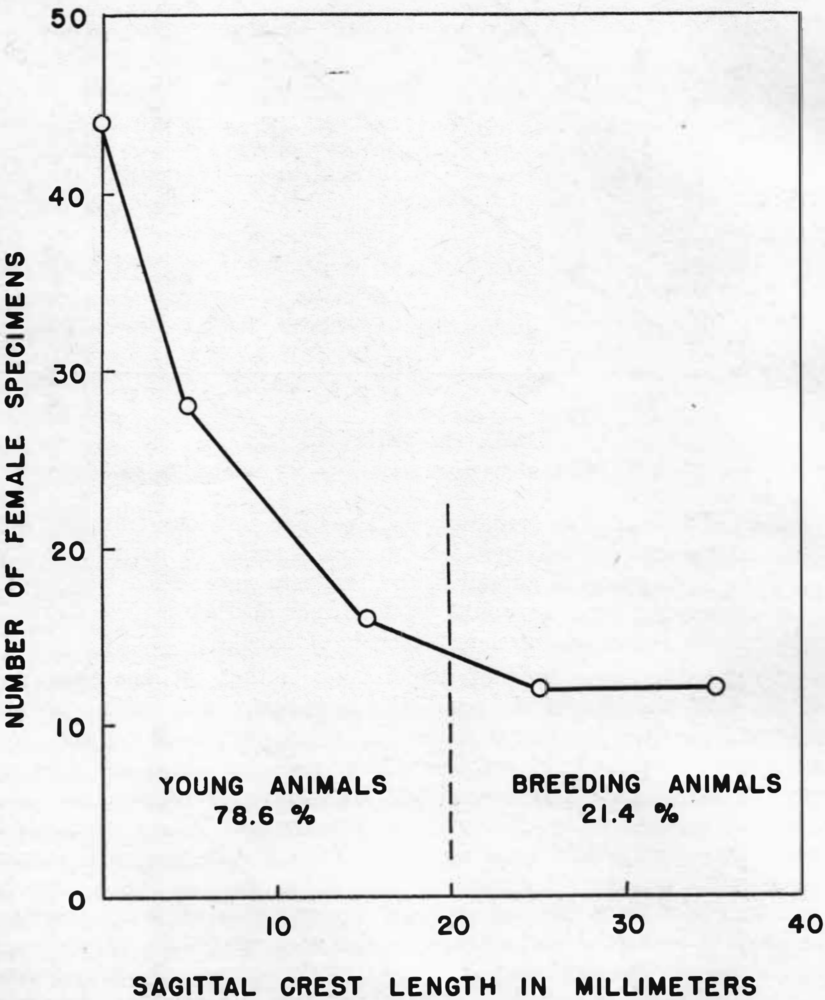

Figure 2: Probable age classification of female marten specimens.

rate but this condition should be expected from trap lines that are intensely trapped year to year.

This resume of the work previously mentioned sketches the results of variable trapping pressure and suggests that criteria for management lie in the control of the timing of trapping and in the spacing of traps. The major biologic characteristic involved is the manner in which the animals naturally distribute themselves in the environment as well as their numerical status. Unfortunately, variations in the level of exploitation cause changes in population characteristics that obscure interpretation and hamper the development of management criteria.

RELATION OF DIFFERENTIAL CRUISING RADIUS TO TRAP PATTERN

Grinnell *et al.* have explained the preponderance of males in catch records on the basis of the wider foraging activity of this sex. However correct this assumption might be, some importance must be accorded to pattern of trap spacing as well as the duration of trapping in connection with predominance of males in kill records.

Male marten are caught at wider intervals along trap lines than females. This is a difficult thing to measure by steel trapping, but became apparent on Michel Parson's line where numbered stations permitted plotting the location of catches. Newby's recent work which more clearly defines the spatial requirements of marten permits an evaluation of the probability of trapping male versus female marten. Newby found that the maximum distance between points of capture and recapture for individual males was 1.6 miles and 0.7 miles for females. The relationship of this biologic characteristic to exploitation can be shown when correlated with trap spacing. For example, an average ten-mile stretch of trap line would have 40 traps operating on it. An even distribution of the sexes along the line, with respect to their differential space requirements, would allot more space to males in proportion to the cruising habits of this sex. The male segment of the population would be exposed to the traps along 6.9 miles of the line. Therefore, 69 per cent of the traps would likely be encountered by males; females would theoretically encounter only 31 per cent of the traps. In this way, although the sexes are equally numerous, the spacing of the traps in relation to the cruising radius of the separate sexes is an important factor in exploitation. This is one of the factors which can be manipulated to adjust or vary the level of exploitation of a species. The other variable, time, was not directly measured by Newby, but nevertheless is demonstrated by the frequency of recaptures that he obtained. His experiments demonstrated that male marten are more susceptible to recapture than females.

The mean frequency of the recapture of males was 9.2 times as compared to 4.4 times for females. Newby's figures indicate that females are approximately twice as "difficult" to catch as males; although this is not a direct measurement of the time-factor it suggests that more time is required to adequately sample the female segment of the population with the same trap arrangement than would be required to capture the male segment of the population. This agrees with the conclusion illustrated in Figure 1 described in a preceding section.

The foregoing discussion has shown that the primary management procedures are the regulation of trap distribution and time-control. These factors can be adjusted to tap either sex class or the broad age classes. This results in a residual population the character of which governs future production. The composition of the population can be varied by the control of exploitation, but several years of application might be required to bring about the desired results.

CRITERIA FOR THE CONTROL OF TRAPPING PRESSURE

Trap spacing or the pattern of trap distribution is a tangible element of trapping pressure. The spacing of traps can be controlled by the distribution of trap lines over an area and by the placement of traps along the lines. The primary biologic factors that determine the efficiency of a given trap pattern are the density of animal populations and the spatial requirements of the different species. These factors are co-variates and cause difficulty in making censuses and in describing ecological relationships. The following discussion refers to the conditions that seemed to prevail during the study in northern British Columbia.

A criterion for adjusting trap spacing is illustrated schematically in Figure 3. Two species, marten and ermine, are used here to demonstrate the relationship of their spatial requirements to a theoretic trap pattern. Within the average home range of a marten seven trap stations occur at the scale shown. A marten would be vulnerable to seven traps but an ermine range would be patrolled by only one trap. Species "vulnerability ratings" might be described as "7" for marten and "1" for ermine; or there is a seven to one chance of catching a marten as compared to an ermine. A "saturated" distribution of ermine over this trap pattern would expose some individuals, but the vast majority of the population would not be vulnerable. While there were more ermine than marten, fewer were caught because the trap pattern was not appropriate for ermine.

A summary of trapping pressure in a spatial sense illustrated in Table 1 shows the relationship of trap line length to area. An average

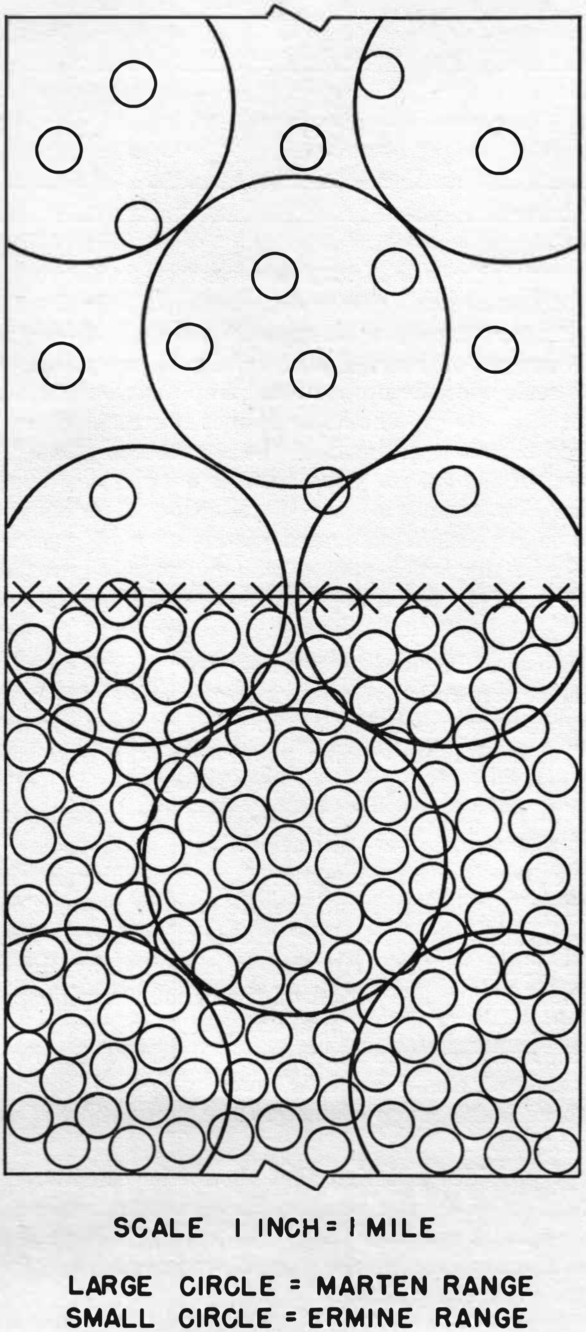

Figure 3: Relation of trap-line spacing to area; relation of trap pattern to marten and ermine distribution.

TABLE 1. AREAS AND LENGTHS OF TRAP LINES IN PHYSIOGRAPHIC ZONES OF THE REGION.

Zone	Number of trappers	Length of line miles	Area trapped square miles	Ratio length to area
Mountain	8	710	5,030	1:7.1
Foothill	12	930	5,220	1:5.6
Muskeg	28	1,193	7,045	1:5.9
Total	48	2,833	17,305	1:6.1

of four traps per linear mile of trap line was used in the region during 1947 and 1948. As a result of the distribution of the lines there was an average of four traps per six square miles. A theoretic pattern of the home ranges of marten and ermine is shown in Figure 3 superposed to scale over the proportional trap distribution that existed at the time of this study. The home ranges represented are approximately average for the two sexes of the separate species. This illustrates that most of the ermine population is not subjected to trapping pressure primarily because of the distribution of traps in relation to ermine home ranges. A saturated distribution of ermine is illustrated to scale in the lower part of the figure to show that only a small proportion of a theoretic population would be exposed to this trap pattern.

This principle can be used to regulate the utilization of different species. Three square miles of area lie to each side of the three mile length of trapline represented in the illustration (Figure 3). In order to further exploit the ermine population trap lines would have to be more numerous and closer to each other. On the other hand, for species with greater spatial requirements the lines must be kept farther apart to prevent over-utilization.

Marten have been the staple winter fur commodity in this region for many years. To adequately utilize the marten population exhaustive trapping must be applied along the existing lines. The animals determine the width of the strip that is exploited by the extent of their movements during the period of time that trapping pressure is applied. In winter, the effects are not likely to reach beyond the diameter of an average home range to each side of the line because the animals tend to remain on their home ranges. If trap lines are closer than three home range diameters the population is vulnerable to over-exploitation.

This concept provides a design that should be considered in planning the utilization of the fur resource in wilderness regions. Regions in which other species are more important require a basic distribution of trap lines appropriate to the spatial requirements of the most important species of fur animal.

SUMMARY

The dominant biologic element involved in fur resource utilization is the variability of the supply. This study has raised the question whether variations of animal abundance are modified by exploitation. If this be the case variable exploitation would activate periodic variation of abundance. The livestock industry is a good example of a case in which the exploitation of an animal population can result in stabilization of the population.

A hypothesis of exploitation is described herein as the basis of a management program for wilderness fur animals. The application of a sex-age class analysis of the kill is a test of the adjustment of the level of exploitation. This is hindsight and measures the success of regulation or management. It also yields an indication of the character of the residual animal population and thus furnishes a basis for predicting productivity. This is using foresight and can justly be called "planning."

Criteria for planning the level of exploitation relate to the timing of trapping pressure and the spatial distribution of traps. The time element of trapping pressure is primarily divisible into two types, (1) duration within one breeding cycle and (2) duration throughout the breeding life of a population cohort. Spatial factors of trapping pressure pertain to the distribution pattern of the sexes in the habitat, spatial requirements of the species and distribution pattern of traps. The application of these criteria should prove useful in fur resource management in wilderness regions. Predator control programs conducted on an extensive scale might also be planned on the basis of these criteria.

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DISCUSSION

MODERATOR CRAWFORD: I am sure that the workers over the country really appreciate an effort like this. We have needed some of these guides for a long time.

Did you indicate, Horace, at what point they were considered to be heavily trapped?

MR. QUICK: In the other paper, upon which this paper is based, I attempted to do that by developing a hypothetical population structure based on the demonstrated sex ratio and demonstrated reproductive rate from case studies. Using these figures, I attempted to show what proportion of a population at any level would be immature animals. With that as a criterion I then attempted to compare the age ratio of the kill to that and my calculations indicated that 35 to 40 per cent of a theoretic group or population would be the young of the year. Therefore, if the catch consisted of more of those, you would be underexploiting from the standpoint of not cutting into your breeding population of females but you would be overexploiting from the standpoint of removing too many young animals. This is a thing that I am still studying and would like very much to sit down and talk about with others of you here who are interested in it.

MR. ANTON DEVOS [Canada]: I find it very difficult to comment on this paper because although we were shown the results of the work we were not shown the sample sexes that he worked with and he also did not give us an impression of the sets of areas that he was considering. I would like to know what personal knowledge he has of these two things and whether he actually used the one set as a control for the other. If he did so, then there are the other variables that would also have to be considered.

I might say that in Ontario we have been running experimental trap lines for six years now and I have made an analysis of our findings and they do not agree with the findings of Mr. Quick.

MR. QUICK: Well, if there was a question there then I am sure that I did not get it. However, I do think that this could be explained if we could get together with our data.

MR. BENSON [Canada]: I am wondering if some of this data is sort of presupposing a very constant trap line in an area where trapping is not done by experienced trappers.

MR. QUICK: From the standpoint of experience, this work was done in a region where people do nothing but hunt for a living. I did not believe that experience was a factor which could be measured, in other words, the type of bait used, the method in which a trap is set; but rather I tried to boil it down to the special distribution of traps and the time of trapping. The matter of what kind of bait and how a trap is set is a very difficult thing to measure and I therefore ruled those things out.

DR. IRVIN BUSS [Washington]: I have heard you say nothing about the difference in behavior between the two sexes.

MR. QUICK: Well, I do not know about that. I don't know how you can take males in preference to females. I know that these professional people have been at it all their lives and they cannot do it. I think that this would be a difficult thing to obtain an evaluation on.

BANDING—A KEY TO DOVE MANAGEMENT

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The Mourning Dove (*Zenaidura macroura* L.) is one of the most avidly pursued migratory game birds in the United States. While it was hunted in only 29 states in the 1955-56 season, the kill by hunters in some of these states was relatively heavy. The mourning dove is unusual among game birds in being multi-brooded. Many local studies indicate the average is about three successful broods per year from five or six nesting attempts. Nests have been found in every month, but the major nesting season is from April to September.

Details of the life history are well known, although very little information on nesting density and production per unit area of representative ecological habitats is available and more studies of these subjects are highly desirable. Annual call counts and monthly roadside counts can be used to detect changes in population and production. Hunter bag checks will denote hunting pressure and hunter success. However none of these techniques provides information on movements and migration of juvenile and adult doves, the origin of doves recovered in various states, the hunter and non-hunter kill, and many other important questions necessary for proper dove management. Only the recoveries from banded doves will provide this desired information.

Mourning dove banding is difficult, time consuming, and costly. From the inception of the banding program in 1920, only 145,000 mourning doves have been banded. Over two-thirds of these were banded in the last seven years during the extensive Cooperative Dove Study. This study originated in ten southeastern states in 1948-49 and gradually spread to include 44 states by 1953. It indicates the possibilities of unified emphasis on banding.

Recoveries from banded doves to December 1, 1955, totaled 5,448. This is approximately 3.7 per cent of the 145,000 banded (Table 1). These have been recovered in many ways, but most were by hunters. About 3 per cent of the banded doves are reported as shot by hunters. Since an unknown percentage of bands are never reported, the kill by hunters may be several times this reported 3 per cent.

During the 36 hunting seasons which have elapsed since banding began in 1920, there have been 5,033 recoveries of doves in the 29 states which had open seasons on doves last year (1955-56) (Table 2). No hunter recoveries are included in this paper from other states which have had dove hunting at sometime during the 36 years. Addi-

[1]In the absence of the author, this paper was read by Dr. John W. Aldrich.

MOURNING DOVE RECOVERIES 1920 - 1955

STATE RECOVERED IN:

STATE BANDED IN:	ALA.	ARIZ.	ARK.	CALIF.	C. A.	COLO.	CONN.	CUBA	DELA.	D. C.	FLA.	GA.	IDAHO	ILL.	IND.	IOWA	KAN.	KY.	LA.	MD.	MASS.	MEX.	MICH.	MINN.	MISS.	MO.
ALA.	234										15	14						2	3	1			1		2	3
ARIZ.		199		2																		11				
ARK.			26		1						1	1		2		1			4			3			2	2
CALIF.				249	1								1									6				
COLO.		1				6																1				
CONN.							5				3															
CUBA								20																		
D. C.																				3						
FLA.	19		3					8			678	21		11	2			5	7			1			4	
GA.	3										2	113		1											1	
IDAHO		3		3									5									6				
ILL.	4		3								13	18		57				1	12						1	
IND.	8		1								12	9		2	24				6			1	1		2	
IOWA																6			1			7				
KAN.						1											8					4				
KY.	10										6	5		1				143	4						2	
LA.	3				1						8	2		4	4			1	539			3		1	13	1
MAN.											1															
MD.										1	1	1								31						
MASS.	10								3		26	41							3	4	20					
MICH.	11										21	25		1	2			1	10	1			15		4	
MINN.			1																					5		
MISS.	3		2								5			2	1	1			15			1			138	
MO.	1				2						6	3		5				1	4			5				75
NEBR.					1											1			1			5				
NEV.				1																						
N. J.	1										1	4								1						
N. MEX.																										
N. Y.	2										7	11							1	2						
N. C.	2										3	7								1		1				
N. DAK.																	1		2			3				
OHIO	23										24	26		2	1				16			3	1		3	
OKLA.	1																1					4				
ONT.												2														
ORE.		6		9																		4				
PENN.	4										6	10														
QUE.																				1						
R. I.																										
SASK.																										
S. C.	1										3	8														
S. DAK.																										
TENN.	5										4	2						1	1						3	
TEXAS	1				4						1	1					3		4			46				1
UTAH		1																				1				
VA.											2	2														
WASH.				1																		1				
W. VA.	1											1														
WISC.	4							1			9	7		1					5			2				
WYO.																										
TOTAL	351	210	36	265	10	7	5	30	3	1	878	334	6	89	34	9	13	155	638	45	20	119	18	6	175	82

STATE BANDED IN:	NEBR.	NEV.	N. J.	N. MEX.	N. Y.	N. C.	N. DAK.	N. S.	OHIO	OKLA.	ONT.	ORE.	PENN.	P.E.I.	R. I.	SASK.	S. C.	S. DAK.	TENN.	TEXAS	UTAH	VA.	WASH.	W. VA.	WISC.	WYO.	TOTAL
ALA.																	2		5	1				1			284
ARIZ.																				2			1				215
ARK.																				17							60
CALIF.		1																									258
COLO.				1																2							11
CONN.																	1										9
CUBA																											20
D. C.						1																					4
FLA.						2			2				1				3		1	2							790
GA.													1				1										122
IDAHO				2																1							20
ILL.																			2	14							125
IND.						2											2			7							77
IOWA	3									3										20							40
KAN.										1										6							20
KY.									1										6	2							180
LA.											1								4	84							669
MAN.																											1
MD.																	3										37
MASS.			1			20		1					1		3		32		1	1		4					171
MICH.						6											4		2	10							113
MINN.																				9							15
MISS.																				4							173
MO.										3										30							135
NEBR.	13									1										6							29
NEV.																											1
N. J.			17		3	4											3		1								35
N. MEX.				2																							2
N. Y.					17	5											5										50
N. C.						229											10					3		1			257
N. DAK.							7													16							29
OHIO						3			78								10		2	7							199
OKLA.										15										10							31
ONT.											1																3
ORE.		3		1								40									1		3				67
PENN.						6							34	1			7					3					71
QUE.																											1
R. I.															1												1
SASK.																2											2
S. C.						2											64										78
S. DAK.										1								5		12							18
TENN.																			127	1							144
TEXAS				3						8										726							798
UTAH																					4						6
VA.						2																6					12
WASH.		1																					9				12
W. VA.																											2
WISC.										1			1				2			12					5		50
WYO.																										1	1
TOTAL	16	5	18	10	20	282	7	1	81	33	2	40	38	1	4	2	149	5	151	1002	5	16	13	2	5	1	,448

tional recoveries may be anticipated from recent banding as some of these doves are still alive. Hunters took 4,279 (85 per cent) of the doves reported from the 29 hunting states, (Figure 1) of which 3,028 were *direct* recoveries—taken in the fall or winter of the same year they were banded. The remaining 1,251 were *indirect* recoveries—secured at least one year after banding and consequently after one or more migrations.

Doves have been banded throughout the year in many states. An unknown number have been banded during migrations, others during winter concentrations, and some on nesting areas. Usually doves have been trapped for banding when they were concentrated and most easily attracted. The emphasis has been most often on getting large numbers banded, but some states have conducted selective trapping of population segments. A few states (especially California, Iowa, Kentucky, Ohio and Texas) have banded considerable numbers of nestlings. Recoveries from these are most valuable since their origin is known, and it is unfortunate that, to date, coverage of this type of banding has been so localized.

There have been 1,221 recoveries of doves banded as nestlings, 22.4 per cent of the total (5,448) recoveries (see Table 3), with 970 (79.4 per cent) of these taken in the state of banding. Of this total, 659 were banded and taken in Texas. Hunters accounted for 1,068 (87.5 per cent) of the nestlings, of which 724 (67.8 per cent) were direct recoveries. Eighty-four per cent of the direct recoveries were in the state of banding (Table 4). The recovery rate from nestling banding is usually somewhat lower than that from older birds, probably due to the high nest mortality (about 50 per cent) of Mourning Doves. However, recoveries of doves banded as nestlings have ranged as high as 3.3 per cent to nearly 7 per cent in Texas and Kentucky.

Many of the doves which were recorded as juveniles when banded must have been raised locally, for 790 (77 per cent) of the 1,026 direct hunter recoveries of juveniles were in the state of banding (Table 4). Only a slightly smaller percentage (72.3 per cent) of the 853 direct hunter recoveries of adult-banded doves were from the state of banding. An even lower percentage (64.7 per cent) of the 425 direct hunter recoveries of doves not aged at banding were from the same state. Table 4 shows 23.9 per cent of the 3,028 direct hunter recoveries were banded as nestlings, 33.9 per cent as juveniles, 28.2 per cent as adults, and 14 per cent were not aged. Three-fourths of the 3,028 were taken in the state of banding, to indicate that of doves which have been banded hunters take three birds from their own state to one bird from other states. The sample is rather small for drawing conclusions too finely, and since many banders do not distinguish

TABLE 2. MOURNING DOVES RECOVERED IN THE 29 HUNTING STATES

State of Recovery	Banded in Same State — Recovered by: Hunter	Banded in Same State — Recovered by: Non-Hunter	Banded in Same State — Total	Banded in All Other States — Recovered by: Hunter	Banded in All Other States — Recovered by: Non-Hunter	Banded in All Other States — Total	Total Recoveries — Hunter	Total Recoveries — Non-Hunter	Grand Total—All Recoveries
Alabama	171	63	234	108	9	117	279	72	351
Arizona	168	31	199	11	0	11	179	31	210
Arkansas	13	13	26	5	5	10	18	18	36
California	193	56	249	14	2	16	207	58	265
Colorado	4	2	6	1	0	1	5	2	7
Delaware	0	0	0	2	1	3	2	1	3
Florida	541	157	698	168	12	180	709	169	878
Georgia	95	18	113	200	21	221	295	39	334
Idaho	5	0	5	1	0	1	6	0	6
Illinois	38	19	57	29	3	32	67	22	89
Kansas	6	2	8	5	0	5	11	2	13
Kentucky	121	22	143	12	0	12	133	22	155
Louisiana	517	22	539	92	7	99	609	29	638
Maryland	19	12	31	12	2	14	31	14	45
Mississippi	111	27	138	29	8	37	140	35	175
Missouri	54	21	75	6	1	7	60	22	82
Nevada	0	0	0	5	0	5	5	0	5
N. Mexico	2	0	2	8	0	8	10	0	10
N. Carolina	157	72	229	47	6	53	204	78	282
Oklahoma	12	3	15	17	1	18	29	4	33
Oregon	37	3	40	0	0	0	37	3	40
Pennsylvania	5	29	34	3	1	4	8	30	38
S. Carolina	59	5	64	78	7	85	137	12	149
Tennessee	95	32	127	21	3	24	116	35	151
Texas	698	28	726	261	15	276	959	43	1,002
Utah	4	0	4	1	0	1	5	0	5
Virginia	1	5	6	9	1	10	10	6	16
Washington	6	3	9	2	2	4	8	5	13
W. Virginia	0	0	0	0	2	2	0	2	2
TOTAL	3,132	645	3,777	1,147	109	1,256	4,279	754	5,033

TABLE 3. RECOVERIES OF MOURNING DOVES BANDED AS NESTLINGS 1920—1955

State Recovered in:

State Banded in:	Ala.	Ariz.	Ark.	Calif.	C. A.	Colo.	Cuba	Fla.	Ga.	Ill.	Ind.	Iowa	Kan.	Ky.	La.	Mass.	Mex.	Minn.	Miss.	Mo.	Nebr.	Nev.	N. Mex.	N. C.	N. Dak.	Ohio	Okla.	Ore.	Penn.	Sask.	S. C.	Tenn.	Texas	Utah	Va.	Wash.	TOTAL
Ala.	5								1						1																						7
Ariz.		7																																			7
Ark.			3												1					1													4				9
Calif.				93													4																				97
Colo.						1																	1														2
Cuba							2																														2
Fla.								3																													3
Ill.	1							4	1	7				1					1													1					16
Ind.	4							4	4	1	5				2		1		1												1		2				25
Iowa												3			1		4										1						14				23
Kan.													2																								2
Ky.	4							4	3					64	2				1													4	1				83
La.	1														25																		3				29
Mass.								1								1													1								3
Man.								1																													1
Mich.	3							2	5						2									1									2				15
Minn.																		2																			2
Miss.			1												4		1		4														1				11
Mo.								3	1					1			1			30													3				39
Nebr.					1							1			1						1																4
N. Y.									1																												1
N. C.																	1							6													7
N. Dak.																									1								6				7
Ohio	3							7	3	2					4				2							23					3	1	2				50
Okla.																	1										6						5				12
Ont.									1																												1
Ore.																												1						1			2
Penn.	1								1																				3		1				2		8
Sask.																														1							1
Tenn.																																4					4
Texas	1				4				1				1		3		42						3				7						659				721
Utah		1																																1			2
Va.									1																												1
Wash.			1														1					1														7	10
Wisc.							1	4	2	1					1		1														2		2				14
TOTAL	23	8	4	94	5	1	3	33	25	11	5	4	3	66	47	1	57	2	9	31	1	1	4	7	1	23	14	1	4	1	7	10	704	2	2	7	1221

TABLE 4. ORIGIN AND AGE AT BANDING OF DIRECT HUNTER RECOVERIES

State of Recovery	Banded as Nestling		Banded as Juvenile		Banded as Adult		Banded as Unknown		Total		
	Recovered		Recovered		Recovered		Recovered		Recovered		
	Same State	Other State	Same State	Other State	Same State	Other State	Same State	Other State	Same State	Other State	Grand Total
Alabama	4	14	44	27	50	17	19	15	117	73	190
Arizona	0	1	41	3	49	4	15	1	105	9	114
Arkansas	1	1	1	0	3	0	1	0	6	1	7
California	58	1	22	8	25	2	23	0	128	11	139
Colorado	1	0	1	0	2	1	0	0	4	1	5
Delaware	0	0	0	0	0	1	0	0	0	1	1
Florida	0	19	277	31	133	32	28	30	438	112	550
Georgia	0	16	9	45	18	34	43	31	70	126	196
Idaho	0	0	3	0	0	0	0	1	3	1	4
Illinois	5	2	9	0	8	7	5	0	27	9	36
Kansas	2	0	0	1	1	2	1	0	4	3	7
Kentucky	56	2	18	3	30	2	2	1	106	8	114
Louisiana	21	17	209	23	144	23	30	10	404	73	477
Maryland	0	0	0	2	8	2	3	4	11	8	19
Mississippi	3	4	19	3	40	4	22	2	84	13	97
Missouri	18	1	3	0	11	3	4	2	36	6	42
Nevada	0	1	0	1	0	2	0	0	0	4	4
New Mexico	0	3	1	1	0	0	0	1	1	5	6
No. Carolina	3	1	75	5	29	15	6	9	113	30	143
Oklahoma	3	2	4	4	3	3	0	0	10	9	19
Oregon	1	0	19	0	10	0	3	0	33	0	33
Pennsylvania	0	1	0	1	0	0	0	0	0	2	2
So. Carolina	0	4	8	22	10	10	20	16	38	52	90
Tennessee	2	4	7	0	16	9	37	5	62	18	80
Texas	422	24	19	54	27	62	11	20	479	160	639
Utah	0	1	1	0	0	0	2	0	3	1	4
Virginia	2	0	0	2	0	1	0	2	2	5	7
Washington	3	0	0	0	0	0	0	0	3	0	3
W. Virginia	0	0	0	0	0	0	0	0	0	0	0
TOTALS	605	119	790	236	617	236	275	150	2,287	741	3,028
Total by Age at Banding	724		1026		853		425		3028		
Percentage of Total	23.9		33.9		28.2		14.0				

easily between juvenile and adult doves, the summary by age at banding may not be a true picture of hunter kill by age group.

Table 5 gives a further breakdown of direct hunter recoveries within the same state as banded. From a total of 2,012 recoveries, 605 were banded as nestlings, 790 as juveniles, and 617 as adults. Over three-fourths of the nestling-banded doves were taken in September; 80 per cent of this kill was in the first half of the month. Hunters thus take a heavy toll of their locally-reared birds. If doves return to nest to the general area where they were hatched, as it is beginning to appear the young of most birds do, some states may be taking too many of their potential breeding stock and thus cutting down their next year's nesting population. In addition to killing much of the production before they migrate, early shooting may include many adults with young in the nest which connot successfully be raised by the remaining parent. This would reduce further their own breeding stock. Mourning dove breeding populations in eastern and southeastern states are in general lower than those of central and western states. Some of this difference may be due to many years of early September shooting combined with greater hunting pressure, which has cut down gradually the nesting population and consequent production.

More juvenile-banded and adult-banded doves have been taken within the states of banding by hunters in September than in other months. This may reflect greater hunting pressure in that month than in later seasons, but also may indicate that many of those juveniles were raised locally and that the adults were nesting nearby. Later harvest of juvenile- and adult-banded birds indicates the birds remain inside the state of banding during the fall and winter months rather than migrating, or that the birds were actually banded near the end of their migration or in winter concentration areas. Contrast the later kill of juvenile- and adult-banded doves with the very few nestling-banded birds taken after early October. The nestlings appear to move out of their hatching areas for late fall migration and for wintering. However, the hunter recoveries present a biased sample which is responsible for more recoveries when hunting pressure is greatest, and they do not provide information on exact migration periods. In other words, we cannot determine when the doves arrived in, or left, certain states or areas, but can tell only when they were taken by the gun. They may have been present in the same area for varying periods before being shot. We can say only that they were there when the gun killed them. We do not know the situation in August before the shooting season opened, or in February after it closed.

TABLE 5. DIRECT HUNTER RECOVERIES WITHIN THE STATE OF BANDING

Banded as	RECOVERED:										
NESTLINGS During	Sept. 1-15	Sept. 16-30	Oct. 1-15	Oct. 16-31	Nov. 1-15	Nov. 16-30	Dec. 1-15	Dec. 16-31	Jan. 1-15	Jan. 16-31	Total
April	10	4	1	2							17
May	57	10	13	5	1	1	4				91
June	100	27	23	7	3	1	1	3	1		166
July	121	30	23	9	2	1	3	3	2		194
August	77	28	12	8	2						127
September			4		1		1	1	1		8
October					2						2
Total	365	99	76	31	11	3	9	7	4		605
Monthly Total	464		107		14		16		4		
Percentage Monthly	76.7		17.7		2.3		2.6		0.7		
Banded as JUVENILES During:											
January				3			1	1	1		6
February								1			1
March	1			1							2
April	3	1	4				2		1		11
May	9	13	10	6			1	9	1	1	50
June	8	43	29	5	1	2	5	12	7		112
July	24	52	22	2	1	1	9	16	11	1	139
August	52	73	19	8			10	32	17	1	212
September	2	18	20	4	3	1	7	21	13		89
October		1	32	43	5		12	30	8	2	133
November					1	1	6	14	3		25
December		1							2		10
Total	99	202	136	72	11	5	53	143	64	5	790
Monthly Total	301		208		16		196		69		
Percentage Monthly	38.1		26.3		2.0		24.8		8.7		
Banded as ADULTS During:											
January	7	4	3	2		3	2	5	5	2	33
February	16	3	4	4	1	1		7	6	2	44
March	16	17	1	3	2	2	1	7	5		54
April	17	16	6	2	3	1	1	13	6		65
May	12	30	5	1	2		2	10	8		70
June	10	34	1	1	1	1	2	5	5		60
July	9	18	3	2	1	2		12	4		51
August	41	16	4	3		1	5	11	4		85
September	1	11	6	3		2	1	5	5		34
October			4	10	8	13	3	8	6	4	56
November					5	4	4	15	9	3	40
December							1	13	11		25
Total	129	149	37	31	23	30	22	111	74	11	617
Monthly Total	278		68		53		133		85		
Percentage Monthly	45.0		11.0		8.6		21.6		13.8		

Figure 1 shows the number of recoveries originating in each state and the number of doves taken by hunters in each of the 29 hunting states. Here the data are biased also, for doves have been banded in greatly unequal numbers in each state, and they have not been subjected to the same gun pressure. Particular emphasis has been given to dove banding in the southeastern states, in Iowa, California,

HUNTER RECOVERIES OF MOURNING DOVES

Texas, and a few other states. Relatively few doves have been banded in most of the north-central and western states.

In this paper the dove recoveries have been analyzed from the standpoint of the states of recovery to emphasize the origin of doves which have been taken in the hunting states. However, only when doves are banded in the nest is their origin certain, although comparison of recoveries of juvenile-banded and adult-banded birds indicate that many of them were raised locally. The dove is highly migratory, and doves recovered in most hunting states are from many other states. However, the average among hunting states is a 75 per cent recovery of banded doves in the same state where banded. This does not necessarily mean that they shoot more doves that were raised in that state than birds raised in other states. To arrive at such a conclusion from the banding data would require the assumption that all populations which might supply hunting in that state had been banded with equal frequency. This we are sure is not the case. The fact that one state shoots a higher percentage of their own production than is shot outside of that state does not rule out the possibility that these same hunters shoot twice as many doves raised in other states, but which are not detected in the recovery sample because of lack of banding in the state of origin. The 5,448 recoveries available for the present analysis, the first ever attempted on a nation-wide scale, are very few for detailed conclusions. Clearly, the most important need for proper dove management is a greatly increased banding program. This should be directed at banding of nestlings in all areas where the species breeds, particularly the more northern sections and the non-hunting states which seem to furnish many doves to the hunting areas. Banding should be conducted throughout the nesting season to sample each brood. With the accumulation of several thousands of additional nestling recoveries, more adequate information will be available to technicians and administrators for better dove management.

SUMMARY

1. The Mourning Dove is one of the most avidly pursued migratory game birds. It is multi-brooded, nesting most commonly from April to September. Life history details are well known, techniques are available to detect changes in population and production, but only recoveries from banded doves will answer many questions necessary for management.

2. Since 1920, 145,000 doves have been banded; 100,000 of these during the last seven years.

3. To December 1, 1955, 5,448 recoveries have resulted, approximately 3.7 per cent of the 145,000 banded. About 3 per cent of the banded doves are reported as shot by hunters; the proportion not reported is unknown.

4. During 36 hunting seasons since 1920, 5,033 recoveries have been secured in 29 dove hunting states. Hunters took 85 per cent of these, and 3,028 were direct recoveries.

5. Doves have been trapped usually where they could be banded in greatest numbers. Only a few states have banded population segments or nestlings.

6. There have been 1,221 recoveries of doves banded as nestlings, which is over one-fifth of the total recoveries, and 79.4 per cent of these were taken in the state where banded. The nestling recovery rate is usually lower than that from older-banded doves.

7. Of the direct recoveries of juvenile-banded birds, 77 per cent were taken in the state of banding, and 72.3 per cent of adult-banded birds were in the same state.

8. Sixty per cent of the direct nestling recoveries in the same state were in the first half of September, and more juvenile-banded and adult-banded birds were taken in September than in later months. This further indicates that hunters are taking many locally raised doves. If hunting were intensive enough this might result in gradual decrease in nesting populations.

9. Recoveries by hunters are a biased sample for several reasons: They can be taken only in the five hunting months; hunting pressure

in all states is not equal; and banding has not been equally distributed among the states.

10. A greatly increased dove banding program is needed, with special emphasis on banding of nestlings in all states.

DISCUSSION

MODERATOR CRAWFORD: This report is, I believe, something that many of the states have long awaited. I think that some of the states felt they would like to have had that information earlier, but we have it now and it is very interesting.

Of course, we do know that the dove does return to its point of rearing. I was wondering if that in itself doesn't give us a good indication of where many of our birds come from.

DR. ALDRICH: Just to enlarge on that—banding of nestlings still must be done before you can determine whether they do go back.

DR. J. J. HICKEY [Wisconsin]: Would you let us know whether there has been an attempt to use more than one band in connection with this program?

DR. ALDRICH: This 3 per cent recovery of birds from the hunters is very discouraging to any bander. There are figures available in the literature that show that the number of returns on waterfowl could be doubled by the use of reward bands.

DR. ALDRICH: There is no doubt that we need some way of appraising the number of bands that are recovered and those which are not recovered. Of course, we have found that many recovered bands are not reported.

There are several objections to reward banding and some of them are of a public relations nature; others are statistical. Of course, moving into such a program can involve a lot of work and expense.

MR. JENNINGS [Texas]: Do you know as yet how many states will participate in the banding program this coming year?

DR. ALDRICH: We have no indication that any states will participate as such, in state programs. We are approaching it this year through our regional offices, using our own men to act as local sparkplugs to get the thing started, to arouse interest in the communities to bet the banding done. Mourning dove banding, of course, is nothing like waterfowl banding. In many cases it is a backyard proposition. The main thing is the volume required. It requires many more dove bandings than it would waterfowl or some species that has a higher rate of return. However, that is our approach at this time and we have no present commitments from any state.

STATUS OF THE WHITE-WINGED DOVE IN TEXAS[1]

WILLIAM H. KIEL, JR. and JOHN T. HARRIS

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White-winged doves (*Zenaida asiatica*) in Texas face an uncertain future. These migratory game birds which winter in Mexico and Central America (Saunders, 1951) have suffered the loss of over 95 per cent of their native nesting habitat in the lower Rio Grande Valley of Texas since 1920. A heavy kill during hunting seasons and unusually high predation losses during the nesting season are other factors which affect the status of whitewings. Hunting seasons were closed in Texas in 1954 and 1955 because of the drastic reduction in fall populations.

We propose to summarize some of the findings of those engaged in white-winged dove studies for the Texas Game and Fish Commission up to the present time and to stress the need for preserving the remnant of native nesting habitat in the lower Rio Grande Valley.

Field investigations for this project were conducted in South Texas, a region bounded roughly on the north by a line drawn from Del Rio to San Antonio to Corpus Christi. The southernmost counties of Zapata, Starr, Hidalgo, Cameron, and Willacy will be referred to as the lower Rio Grande Valley.

ACKNOWLEDGMENTS

This report relies on the contributions of personnel of Pittman-Robertson Projects 1-R and W-30-R of the Texas Game and Fish Commission. Unless otherwise designated, data in the text are derived from project reports which are listed in the literature cited section. E. G. Marsh conducted studies in 1939 and 1940, and N. N. Nilsson followed in 1942 and 1943. From 1947 through 1951 P. B. Uzzell was project leader; assisted in 1947 and 1949 by T. D. Moore; in 1948 by Moore and S. P. Gordon; in 1950 by Moore, W. S. Jennings, and J. D. Taylor; and in 1951 by Jennings and A. J. Springs. In 1952 and 1953 W. S. Jennings was project leader with J. T. Harris acting as his assistant. Harris was assigned as leader for 1954 and 1955 with R. L. Downing as assistant in 1954 and W. H. Kiel, Jr. in 1954 and 1955. Kiel currently is assigned as project leader.

We gratefully acknowledge the important contributions made to the white-winged dove project by State Game Wardens of South Texas who have participated in many of the activities. Our thanks go to E. A. Walker and W. S. Jennings, Texas Game and Fish Com-

[1]Contribution from Federal Aid in Wildlife Restoration Project, Texas W-30-R.

mission, for critically reading the manuscript, and to Mrs. G. R. Ziegenbein for typing assistance.

CHRONOLOGY OF THE BREEDING SEASON

Whitewings begin to arrive in Texas from their winter quarters in late March and increase in breeding numbers until late May. Peak of the nesting season as measured by active nests falls between June 15 and July 15. Nesting gradually declines to the end of the breeding season in late August.

Toward the end of the nesting season, whitewings begin to gather in flocks and form regular flights to choice feeding areas. Southward migration normally begins in September, and by October 15 almost all of the birds have left the lower Rio Grande Valley for their winter range.

EARLY POPULATIONS AND HABITAT

In the early 1920's fall flights of whitewings were estimated at 3 to 4 million birds (Jones, 1945). Nesting colonies sometimes numbered 50,000 whitewings, and many such colonies were located in the thousands of acres of brushland along the banks of the Rio Grande and the Arroyo Colorado. A single feeding flight often contained over 200,000 birds, according to Jones' estimates.

By 1930 a substantial decrease in whitewings was evident. Thousands of acres of nesting, feeding, and roosting habitat had been cleared for cultivation, and hunting pressure had increased. In 1926 and 1927, legislation allowed hunters to kill whitewings on July 1, the peak of the nesting season. Since then the opening date has been moved back gradually into September. A severe drouth, which adversely affected nesting cover and food, combined with intensified land clearing preceded a population low for whitewings in 1938. Fall flights were estimated at 500,000 birds in 1939 and 100,000 in 1940. In the latter year, a shortage of native food, principally goatweed (*Croton* spp.), evidently caused whitewings to migrate southward into Mexico earlier than usual. Considerable movement in search of food is characteristic of fall whitewing populations. Feeding flights commonly moved from the lower Rio Grande Valley grain fields, principally hegari and maize, to ranchland north of the Valley to feed on native foods such as goatweed and leatherweed (*Jatropha spathulata*) when weather conditions favored an abundant crop of seed.

In 1940 about 5,000 acres of native nesting cover remained in Hidalgo, Cameron, and Willacy Counties, the region of greatest importance for whitewing nesting in South Texas. Several hundred thousand acres of brushland had been cleared since 1920, and enlarged irrigation districts threatened the remaining whitewing nesting cover. In many instances drainage of surface water in connection with farming activities reduced the quality of the remaining brush for nesting birds.

POPULATIONS AND HABITAT SINCE 1947

Fall populations. Beginning in 1947, fall-flight estimates were aided by aerial reconnaissance used to locate whitewing flights which were later estimated from the ground. Estimating numbers by aerial observation was found to be impractical. Ground estimates of flights were made by counting birds passing per unit of time and timing the duration of the flight. Fall-flight estimates were made in September just prior to the hunting season. An undetermined margin of error must be allowed in estimating several hundred thousand birds, but we feel that major trends in the population as shown in Table 1 can be determined reliably.

During the fall period, whitewings follow the routine of roosting in brushland, forming early-morning feeding flights to grain fields or ranchland, spending midday in the vicinity of the feeding grounds, feeding in the afternoon, and returning to the roosting grounds before dark. Watering habits seem to depend to a great extent on the distance of watering sites from feeding grounds. Watering periods immediately following feeding activity are most common.

We have no recorded estimates of fall populations from 1941 until 1946, the year in which an unusually large concentration of 2 million whitewings was found in the lower Rio Grande Valley area. In 1947, fall flights were down to 80,000 birds but in 1948 rebounded to 800,000 (Table 1). The low fall population of 1947 coincided with a scarcity of both native food and domestic grain. Heavy rains in South Texas might have been a factor in moving the whitewings into Mexico ahead of schedule. The shortage of native foods on ranchland continued during the fall seasons of 1948 through 1950, but domestic grain held 800,000 to 900,000 whitewings in the lower Valley.

Following a great drop in spring-breeding numbers, populations in the fall of 1951 declined markedly to 175,000 birds. Native food and domestic grain were available in fair supply. Fall flights in 1952 were of the same magnitude. Both in 1952 and 1953, whitewings disappeared in large part from the Valley area at the close of the nesting season in mid-August, only to reappear in Texas prior to the hunting season. It is likely that these birds moved southward in search of food and returned to the Valley when domestic grain crops ripened. In 1953, the birds apparently exhausted their food supply, and the early-fall population dropped from 120,000 to 53,000 before the hunting season opened.

In 1954 and 1955, goatweed was abundant but domestic grain scarce. Whitewings left the lower Valley at the close of nesting and did not reappear in large numbers. Indications are that the birds have been moving south into Mexico, because wardens and other observers over South Texas did not report large feeding flights in the region. The lowest fall population on record is 8,000 whitewings estimated in 1955.

Spring populations. Breeding populations in native brush and citrus groves were estimated in 1950 and subsequent years (Table 1). Estimates of breeding density are based chiefly on call-counts. Intensive nesting studies in concentrated nesting areas help observers in estimating populations of such high density that individual coos are obscured and a continuous volume of sound is produced instead. Variations in cooing activity caused by such factors as time of day, stage of the breeding cycle, and nesting density affect the accuracy of breeding population estimates to an unknown extent. Attempts are made to conduct the annual breeding censuses in a comparable manner in order to minimize these variables and to determine trends with reliability.

As native habitat dwindled, whitewings gradually began to nest in citrus groves in the mid-1940's. The older, densely foliated trees were preferred. Nesting in citrus increased markedly in 1949, and in 1950 over 80 per cent of the estimated 1,039,000 whitewings in the lower Rio Grande Valley were using citrus nesting cover. A severe freeze in the winter of 1950-1951 destroyed 85 per cent of the citrus trees whitewings had used in 1950, and in 1951 the breeding population dropped to 110,000 birds which resorted chiefly to native brush. Since then, breeding numbers have remained relatively stable, fluctuating from 115,000 to 214,000 birds.

Citrus groves were replanted after the 1950-1951 winter, but since then whitewings have used only the widely scattered groves of older trees that survived the freeze. In 1955, 75 per cent of the breeding population was found in Hidalgo, Cameron, and Willacy Counties in approximately 1,200 acres of native brush—the last remnant of suitable native nesting cover in the lower Rio Grande Valley.

HUNTING STATISTICS

The hunting statistics shown in Table 1 were gathered through hunter-check stations and aerial surveys. Aerial counts were made to determine the number of vehicles in the hunting zones. Directions printed on paper bags, given out at check stations prior to the hunt,

TABLE 1. WHITE-WINGED DOVE POPULATIONS AND HUNTING STATISTICS. LOWER RIO GRANDE VALLEY.

	Populations					Doves	Age ratio of bagged doves	
Year	Spring breeding	Fall hunting	Doves bagged	Per cent of fall population bagged	No. hunter-days[1]	per hunter-day	Sample size	Young:Adult
1947	No census	80,000	44,868	56	13,063	3.4	478	1.2 : 1
1948	No census	800,000	144,362	18	21,657	6.7	11,975	2.2 : 1
1949	No census	800,000	218,365	27	28,940	7.5	13,359	2.1 : 1
1950	1,039,000	900,000	203,440	23	28,721	7.1	33,664	1.1 : 1
1951	110,000	175,000	27,883	16	19,139	1.5	4,855	0.6 : 1
1952	214,000	176,000	117,324	67	19,735	5.9	7,481	1.1 : 1
1953	137,000	53,000	28,514	54	14,800	1.9	2,181	0.6 : 1
1954	115,000	50,000	Closed season					
1955	142,000	8,000	Closed season					

[1]A hunter-day is defined as one hunter in the field for one day of the season. Since 1947, there has been a 3-day open season with shooting hours from 4:00 p.m. to sunset (approximately 2½ hours of shooting time per day).

requested hunters to record the number of hunters in the car, number of whitewings bagged, number of whitewings wounded or killed and not retrieved, and to place in the bag one leg from each whitewing killed. Bags were dropped at a check station as the hunters left the hunting area.

Since 1947, the hunting season has opened about the middle of September for three alternate days, with shooting hours from 4:00 p.m. to sunset and a bag limit of 10 whitewings and/or mourning doves per day.

Hunting whitewings reached a peak of popularity in 1949 and 1950 when over 28,000 hunter-days were spent in the field (Table 1). Hunts were publicized widely by Rio Grande Valley business interests, for the influx of whitewing hunters became an important source of income to the area. To locate feeding flights of birds, non-residents of the area commonly would follow cars of local hunters streaming to the choice flight lanes. Cars lined up almost bumper to bumper along farm roads in the flight path of whitewings, and few hunters bothered to take cover while shooting. Number of hunter-days declined after 1950, due in part to adverse hunting conditions caused by rainy weather in 1951 and 1952 and the realization in 1953 that whitewings were present in only a small percentage of their former numbers.

There is evidence that a higher percentage (average 59 per cent) of the whitewings are killed when the population is low, as in 1947, 1952, and 1953, than in years of relative abundance—1948, 1949, and 1950 (average 23 per cent). On the surface the 1951 season gave contrary results, but adverse hunting conditions caused by heavy rains and impassable roads kept the kill low. However, hunter reports of unretrieved killed or wounded birds were 66 per cent of the total bagged birds in that year.

Reported unretrieved loss of whitewings has ranged from 16 to

66 per cent of the bagged-bird total from 1949 through 1953, and averaged 24 per cent excluding 1951. The true loss is difficult to assess because an unknown portion of the birds reported as unretrieved are picked up by other hunters. Hunter firing lines in some instances are bounded on one side by dense native brush and cactus cover. In such cases many hunters fear rattlesnakes (*Crotalus atrox*) and are reluctant to enter the brush to retrieve downed doves—a reluctance not without some grounds but conducive to wasteful harvest of whitewings.

To determine the age ratio of bagged birds, whitewings were classed as young of the year or adults on the basis of leg color. Young birds have brownish to light pink legs compared to a purplish-red leg color in adults. This ageing technique was checked by examining dead birds for the presence of a bursa and was found reliable during the September hunting season.

Young to adult ratios in bagged birds (Table 1) generally have been higher than one would expect from the hatching and fledging success recorded for whitewings (Table 2). At present, we can only speculate on the factors influencing the age ratios obtained during the hunting season. Differential movements of age groups or differences in vulnerability to hunting could influence the bagged-bird age ratios. On the other hand, nesting studies depending on areas of high nesting density for the bulk of data might be misrepresenting the overall hatching and fledging success.

TABLE 2. WHITE-WINGED DOVE NESTING STATISTICS. SOUTH TEXAS AND LOWER RIO GRANDE VALLEY.

Year	Region	Habitat	No. eggs	Per cent hatched	No. young	Per cent fledged	Per cent of eggs fledging young
1947	South Texas[1]	Native brush	1,302	60.6	789	92	56
1948	South Texas	Native brush	462	50.9	235	87	44
1949	Rio Grande[2]	Citrus groves	920	54.7	503	89	49
1950	Rio Grande	Citrus groves	1,855	37.3	692	74	28
1951	Rio Grande	Citrus and brush	1,226	41.7	511	90	37
1952	Rio Grande	Citrus and brush	1,384	31.5	436	82	26
1953	Rio Grande	Citrus and brush	1,081	20.1	217	72	14
1954	Rio Grande	Citrusand brush	991	36.1	358	82	30
1955	Rio Grande	Citrus and brush	1,074	36.8	395	82	30

[1]Studies conducted principally in Live Oak, Webb, Val Verde, Maverick, Frio, Bee, Dimmit, Uvalde, La Salle, and Medina Counties.
[2]Studies conducted in Hildago, Cameron, and Willacy Counties.

NESTING STUDIES

Methods. Nesting study areas in the nature of transects or quadrats were established on an annual basis in the lower Rio Grande Valley. Study areas varied from one-fourth to more than two acres in size and were located to sample nesting densities ranging from less than

10 pairs to more than 100 pairs per acre. Individual nests were followed through the nesting season and checked at weekly intervals, if possible. Observations were made by the use of a mirror-on-rod device which eliminated most of the tree-climbing phase of a whitewing nesting study. In upper South Texas where nesting was dispersed, nests were checked at random rather than on study areas.

Nesting cover. Whitewings prefer a densely foliated, brushy native cover for nesting. Their nests are constructed poorly of twigs and require a closely interwoven substrate for support. Ebony (*Pithecolobium flexicaule*), huisache (*Acacia farnesiana*), and granjeno (*Celtis pallida*) are some species heavily used as nesting cover. Understory species such as guayacan (*Porliera angustifolia*), whitebrush (*Aloysia ligustrina*), and cactus (*Opuntia* spp.) vary with soil moisture and degree of canopy closure. In native cover of the lower Rio Grande Valley, the great majority of nests are built in a range from seven to twenty feet from the ground. Four to six nests in a single tree are not unusual.

Citrus trees apparently are not used to an appreciable extent as nesting cover until a height of approximately 12 feet is reached. Only scattered older groves which survived the freeze during the 1950-1951 winter are of the quality desired by nesting whitewings.

Predation. Nesting statistics reported in Table 2 reveal the role of predation in whitewing nesting. The extremes in percentage of eggs fledging young are 56 per cent in upper South Texas in 1947 and 14 per cent in the lower Rio Grande Valley in 1953. The very low fledging success was due in part to severe drouth which caused a shortage of native and domestic foods and apparently shortened the nesting season, which terminated the first week in August. Studies in upper South Texas were conducted on an extensive basis and included many areas having a low nesting density of less than 10 pairs per acre. Lower Valley study plots were located both in high (50 to 200 pairs per acre) and low nesting-density areas.

Principal predators are great-tailed grackles (*Cassidix mexicanus*) and, to a lesser extent, green jays (*Xanthoura luxuosa*). We have seen grackles force the incubating adult whitewing off its nest and then eat the eggs or young. Grackles will kill and eat young whitewings old enough to fly short distances. The predator-prey relationship seems aggravated because grackles and whitewings nest in close proximity, frequently in the same tree, in both native brush and citrus.

Once hatched, about 80 to 90 per cent of the young fledge successfully in most years. The higher than usual loss of young (26 per cent) in 1950 was attributed to grackles and house rats (*Rattus rattus*), which were abundant in citrus groves having a heavy ground cover of grass and weeds. In 1953, however, a 28 per cent loss of nestlings was attributed almost entirely to grackles. In some localities house cats cause serious loss of young whitewings, for the young birds are easy prey for cats, especially in citrus groves near farm buildings.

Attempts to control predators, chiefly great-tailed grackles, through live trapping and harassment with shotgun fire, fireworks, and flares were successful to a limited degree, but not to the extent of being practical on a large scale.

Production. Whitewings lay two eggs per clutch, incubate about 14 days, and the young fledge 14 days after hatching. Generally, nesting begins in May and continues well into August with a peak of active nests from June 15 to July 15. There is ample time for several broods of young to be reared. Fall age ratios obtained from hunters' bags have shown as high as 2.2 young per adult and thus offer indirect evidence of two or more broods per pair for a season. An individual nest rarely produces two broods of young, although it may have two or three sets of eggs during the season.

We feel that whitewings attempt to rear two or more broods in a season. Predation plus nesting cover and food deficiencies seem to allow only limited success, however. Attempts to capture, mark, and subsequently observe adult nesting birds for renesting studies have not been successful.

UPPER SOUTH TEXAS STUDIES

In conjunction with whitewing investigations in the lower Rio Grande Valley, studies also were made of breeding and fall populations in counties to the north. The breeding population in upper South Texas is estimated to constitute less than 5 per cent of the whitewings in Texas. Nesting in this generally dry region is chiefly along stream beds and in towns and cities. Hunting-season flights have been erratic due to drouth-inflicted food shortages, and kill, as estimated by wardens, has been generally less than 5 per cent of the Texas whitewing harvest.

There was some optimism in the 1940's that whitewings, forced from their native Valley habitat by land-clearing activities, would move northward to nest in upper South Texas (Tucker, 1944). Such movement has not materialized. Populations have fluctuated, but no general upward trend has been recorded.

NORTHEASTERN MEXICO SURVEY

A reconnaissance to determine the nesting distribution and abundance of whitewings in northeastern Mexico was made in 1950. In subsequent years, call-count transects and feeding-flight census areas have been established and checked annually. Three major nesting areas have been located in the State of Tamaulipas: one along the Rio Conchos east of San Fernando; another east of Ciudad Mante; and the third and apparently largest in the bottomland of Rio Soto la Marina east of Padilla. Due to the inaccessible nature of these areas, no estimates of total populations have been possible.

June surveys have indicated that breeding populations in northeastern Mexico declined sharply after 1950, and only in 1955 was an upward trend noted. Severe drouth during the early 1950's and a freeze south to Ciudad Mante in the 1950-1951 winter are probable reasons for the decline.

BANDING

Whitewing banding, principally of nestlings, has been done in Texas intermittently since 1940 and in Mexico in 1951. Of the 7,465 birds banded from 1940 through 1952, 320 were banded in Mexico in 1951. Texas banding was concentrated in the lower Rio Grande Valley.

Through April, 1953, about 4 per cent of the bands had been recovered. Of the 323 recoveries, 304 were taken in Texas, 13 in Mexico, and 6 in Central America. No birds banded in Mexico have been recovered. Of the total recoveries, 71 per cent were taken within three months after fledging. Eighty-five per cent of the Texas recoveries were made within 40 miles of the banding site, and no definite migration routes were discernible.

The 13 Mexican recoveries were as follows: six within a few miles of the Texas banding site; three in the State of Oaxaco; and one each in the States of Morelos, Vera Cruz, Guerrero, and Chiapas. There were six recoveries from Central America—two each from El Salvador, Honduras, and Guatemala. On the basis of these band recoveries from Mexico and Central America and the observations of Saunders (1951), it appears that the Texas whitewings migrate southward along the coastal plain of Tamaulipas and Vera Cruz to the Isthmus of Tehuantepec and then disperse along the Pacific Coast of Mexico and Central America.

DISCUSSION

We believe that the future of the white-winged dove in Texas, in the status of a game bird, is not at all secure. Our knowledge, admittedly incomplete, is restricted almost entirely to the segment of the whitewing population which breeds in Texas.

Summer and fall movements. We need to know the nature of movements occurring between Mexico and Texas during the late summer and fall. With the exception of 1951, the spring-breeding population has exceeded the fall hunting-season population of whitewings in the lower Rio Grande Valley, so there is evidence that Texas-reared birds often move into Mexico prior to the Texas hunting season. Such southward movements have been noticeable particularly since 1953 and have coincided with a scarcity of domestic grain in the lower Valley area. In recent years, the trend has been away from growing grain on a modest scale for livestock feed on many irrigated farms. Instead, grain is grown chiefly in dry-land farming sections on a large scale and is either abundant in a wet year or practically nonexistent in dry years.

The early southward movement of Texas whitewings in recent years allows speculation that over a period of years, early-migrating birds have escaped the Texas hunting season and have a higher survival rate than late migrants subjected to heavy hunting pressure. It seems possible that a tradition of early migration might be formed in this fashion.

For a sound management program, we need to know how whitewings are faring on their wintering grounds in Mexico and Central America. Having whitewings listed on the menus of restaurants in Mexican border cities arouses some United States citizens to protest. On the other hand, it is apparent that many hunters from the United States have no scruples about shifting their hunts south of the border now that the Texas season is closed.

Vulnerability to hunting pressure. Because whitewings are gregarious and routine in feeding habits, their flights are located easily by hunters, and no particular skill is required to hunt them. Hunting interest is high, for the birds are fine targets and highly esteemed on the table. With modern means of publicity and transportation, small fall populations are in danger of being subjected to unusually high hunting mortality.

Preservation of native nesting habitat. In view of the fact that over 95 per cent of the native nesting habitat of whitewings in the lower Rio Grande Valley has been cleared for cultivation, it is rather late to urge the preservation of native brushland for whitewing nesting cover. It should be pointed out that this plea is only an echo of many earlier reports, made since 1940 by Marsh, Nilsson, Uzzell, Jennings, and others, recommending that some whitewing nesting grounds be preserved. To trace the negotiations for land purchase in the lower Valley by the State of Texas would be pointless here. It is sufficient to say that no land has been set aside for whitewings, and that land offers once spurned would now be considered a bargain. Land prices have boomed in the irrigated region of the Valley.

We urge that land now being used by high concentrations of whitewings be purchased or leased on a long-term basis. In 1955, we found 75 per cent of the breeding population using about 1,200 acres of brushland, distributed in small tracts in Hidalgo, Cameron, and Willacy Counties. We believe that preserving some of these areas would be highly desirable for several reasons. They are known to be used annually by nesting colonies. History of use is important, for some high-quality cover, in our estimation, is not used by whitewings to the degree expected. For example, the Santa Ana National Wildlife Refuge, established in 1943 in Hidalgo County, comprises just under 2,000 acres of brushland and river-bottom timber. Yet the nesting whitewings have numbered only about 3,000 to 5,000 birds for the past several years, and these have concentrated in two or three rather restricted areas on the refuge. Hence it seems important to preserve areas with known nesting concentrations.

In addition to the constant land-clearing activities, native brushland of the lower Rio Grande Valley is threatened by a lowered water table resulting from deep drainage ditches needed to carry off surplus irrigation water. This means that brush tracts must be managed for whitewings, not merely set aside as sanctuaries.

Native habitat is needed for further research into the nesting ecology of whitewings and great-tailed grackles. We need to evaluate the renesting factor in whitewing production and better understand the role of predation.

It might be argued that citrus groves will again provide nesting cover for the bulk of the breeding population as in 1949 and 1950, and therefore preservation of native cover is not necessary. We need look only to the freeze of the 1950-1951 winter and the resulting destruction of citrus to explode this point. Since whitewings have made little use of citrus trees less than 12 feet tall, the outlook after a severe freeze will be bleak indeed, if no native nesting cover is available.

We believe that, aside from its value to white-winged doves, some remnant of the native brushland in the intensively farmed lower Rio Grande Valley will be appreciated by residents and visitors to the Valley in years to come.

SUMMARY

The white-winged dove in Texas faces an uncertain future in its status as a game bird.

Fall flights of whitewings in the lower Rio Grande Valley were estimated at 3 to 4 million birds in the 1920's. Native habitat was cleared for cultivation and hunting pressure increased for the next 30 years. Fall populations fluctuated greatly, apparently in response

to variations in food supply. The hunting season was closed in 1954 and 1955 when fall flights dropped to 50,000 and 8,000 whitewings, respectively.

Nesting cover of native brush has been largely eliminated. Whitewings were concentrated in the few remaining brush tracts and were nesting heavily in citrus groves before a severe freeze in the 1950-1951 winter destroyed 85 per cent of the citrus used for nesting. Spring estimates of breeding birds dropped from 1,039,000 in 1950 to 110,000 in 1951 and have fluctuated from 115,000 to 214,000 since then. In 1955, 75 per cent of the breeding population was found in approximately 1,200 acres of brushland left in scattered small tracts in the lower Valley.

Hunting whitewings reached a peak of popularity in 1949 and and 1950 when more than 28,000 hunter-days were spent in the field. Open seasons since 1947 have been in mid-September for three alternate days with shooting hours from 4:00 p.m. to sunset—an open season of about 7½ hours per year. Over 200,000 whitewings per season were bagged in the peak years of 1949 and 1950. Hunters found the regular feeding flights easily accessible and bagged a higher percentage of the fall population when flights were small than in years of abundance.

For nesting, whitewings prefer densely foliated cover of the ebony-huisache type. Only the older citrus trees more than 12 feet tall have been used to an appreciable extent. Predation by great-tailed grackles and green jays is the principal factor in reducing fledging success since 1950 to approximately 30 per cent of the eggs laid.

Studies in upper South Texas show that not more than 5 per cent of the Texas breeding population nests outside the lower Rio Grande Valley. Surveys in northeastern Mexico have located three major nesting colonies in the State of Tamaulipas. Breeding populations there have shown a general downward trend since 1950, apparently due to severe drouth and the freeze of 1950-1951. Banding in Texas indicates that whitewings migrate southward along the coastal plain of Tamaulipas and Vera Cruz to the Isthmus of Tehuantepec and then disperse for the winter along the Pacific Coast of Mexico and Central America.

Preservation of native brushland is desirable to provide dependable nesting cover for whitewings; to afford opportunity for further research into the nesting ecology of whitewings and great-tailed grackles; and to maintain a remnant of native flora for the historical benefit of residents and visitors to the intensively farmed lower Rio Grande Valley. Biologists have recommended repeatedly since 1940 that native nesting grounds be preserved by long-term lease or purchase by the State. Land prices have skyrocketed and available acreage of brushland has decreased, but no tracts have been preserved for white-winged doves.

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DISCUSSION

CHAIRMAN PATTERSON: I think that you will recognize that this last paper could be one of the most significant presented at this entire conference. It points out the problem of the white-winged dove in Texas and I think it may be obvious to you that the white-winged dove may well be joining one of the endangered species on this continent.

MR. SAUNDERS [Fish and Wildlife Service]: I would like to say that I had the pleasure of working in the lower Rio Grande valley some years ago in connection with the white-winged dove. Back in 1938 both the Fish and Wildlife Service and the State Game Commission received a number of letters from hunters down in the valley reporting the flight of this species. We began our investigation at that time as a joint project. It was soon learned that most of the hunters in that district believed that practically all of the white-winged doves were produced in Mexico and came north for our benefit along about hunting season, and therefore there was no reason for us here in the states to be concerned about this bird and that the supply from down in Mexico would continue to be as it had been.

Therefore, both the Service and the State Game Commission began a study to find out just where those birds were produced and in our first season of work, which was in 1940, we learned that many nesting grounds were populated there in the valley and then we also did some work on the Mexican side of the river and found that many colonies were present there. That summer we banded about 2200 nestlings and then kept up with the flights that formed in the late summer and with those that were distributed over the valley during that hunting season. We found that most of the birds that were available for the hunters were produced in the immediate area, in the lower Rio Grande Valley. Our observations indicated that there were on appreciable flights form the interior of Mexico—far beyond the confines of the lower Rio Grande Valley. We have continued this study ever since then and we have found that the only times that we received any appreciable influx of birds from farther down in Mexico was either in a season of unusual drought, which resulted in a scarcity of food, or when a hurricane happened to come in. We have no record of any really great flights coming from the interior of Mexico.

MR. CALEB GLAZNER [Texas]: Is it true that in February of 1955 there was approved by the U. S. Fish and Wildlife Service a federal land acquisition project, the preliminary statement of that covering the purchase of a nesting and roosting area in the Rio Grande valley?

MR. KIEL: That is correct.

MR. GLAZNER: Was there any further action taken leading to the actual purchase of that area?

MR. KIEL: No, not to my knowledge.

MR. GLAZNER: Is it true that as of June 30, 1955 there reverted from the Texas allocation of federal aid funds to the Migratory Bird Fund more than enough money to have purchased a significant segment of such area?

MR. KIEL: That is right.

MR. GLAZNER: Would there also have been sufficient funds to have purchased the 100-acre tract that you mentioned?

MR. KIEL: Yes, I think that funds in the amount of $333,000 would have bought quite a bit of the necessary habitat. I would like to point out that the final responsibility for making a decision to purchase this habitat in the Rio Grande Valley rests with the Texas Game and Fish Commission.

TECHNICAL SESSIONS

Tuesday Morning—March 6

Chairman: Albert W. Collier
Chief, Gulf Fishery Investigations, U. S. Fish and Wildlife Service, Galveston, Texas

Discussion Leader: D. W. Pritchard
Director, Chesapeake Bay Institute, Annapolis, Maryland

MARINE AND COASTAL RESOURCES

EARLY LIFE HISTORY OF THE GULF MENHADEN, *Brevoortia patronus*, IN LOUISIANA[1]

Royal D. Suttkus
Tulane University, New Orleans, Louisiana

The study of the Gulf menhaden was conducted on Lake Pontchartrain and adjoining waters from July, 1953 to May, 1955. Repeated sampling with fine-meshed push nets and catch records from trawls and seines indicate that menhaden do not spawn in the lake. However, during each winter larvae appear in the lake, remain for their first summer of life, and then move out in the fall presumably to the open waters of the Gulf or at least to the mouths of the estuaries and outer regions of the sounds.

Menhaden larvae made their appearance in the lake in December of each of the two winters during the study. Larvae 20 to 30 millimeters in total length move into the lake from December through March (Table 1). Presumably spawning (no direct observations) begins in October and ceases in February. No doubt the beginning and end of the spawning period fluctuates from year to year. Regardless of the exact limits of the spawning season there apparently is no spawning during the summer months as reported for northern populations of *Brevoortia tyrannus* by Kuntz and Radcliffe (1917).

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[1] Material was obtained during a biological study of Lake Pontchartrain, a cooperative investigation by the Zoology Department, Tulane University, and the Commercial Seafoods Division, Louisiana Wildlife and Fisheries Commission.

DESCRIPTIONS OF LARVAE AND YOUNG

The following descriptions of larvae and young are based on specimens contained in the following catalogued series of the Tulane University collection: Tu 7129, 8109 and 9671. Each description is preceded by the standard length measurement expressed in millimeters.

18.9 mm. (TU 7129)—A single melanophore is present at the base of the pectoral fin; two large melanophores on isthmus; a double row of large melanphores on ventrolateral area of body, eight in left row, nine in right row; large melanophores on dorsal part of lining of body

TABLE I
LENGTH FREQUENCY DISTRIBUTION OF GULF MENHADEN (*Brevoortia patronus*) TAKEN FROM LAKE PONTCHARTRAIN, LOUISIANA, JULY, 1953 TO MAY, 1955

	1953						1954												1955				
mm.	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
0- 4																							
5- 9																							
10- 14																							
15- 19									1														
20- 24										2								10	9	4	14		
25- 29						12	1		10	15	5							15	97	264	47	20	2
30- 34						1	2		13	23	23							5	6	113	104	54	10
35- 39							1			54	105	3								5	281	191	54
40- 44										48	168	6								1	409	261	70
45- 49									2	51	185	2								1	171	153	89
50- 54										60	301	2									70	72	239
55- 59										72	578	46	1								17	34	162
60- 64										67	521	42	1								2	16	149
65- 69										62	216	30		1							4	3	154
70- 74										19	47	23	1	4							2	1	136
75- 79		1								9	15	8		12							2		78
80- 84		2								3	16	1	3	35									24
90- 89	1	1								2	13	1	1	60	2								4
90- 94	1										6	2	12	39	4								3
95- 99	1	1	2	1							9		45	21	8								1
100-104			5								3		35	7									
105-109	1		9									1	59	3			1						
110-114	1	3	21									1	66	2				1					
115-119	1	6	71							1		1	53	2				1					
120-124	1	3	105	1	2			1					37	3		1	2	1					
125-129		3	139		2						1		39	15	1			1					
130-134		1	81		4								14	14		1					2		
135-139		5	33	1	1								2	30		1	3	4	3	2			
140-144			25	1								2	4	28			4	3	2	3	1		
145-149		1	20	2								5		14			11	2	2	2	3		
150-154			9	1	1							10	1	8			9	1	2		1		
155-159			1		1								1	3	1		3	1		1	4		
160-164			1									7	1	3			3			3	4		2
165-169			5									5	2	5			3				1		
170-174		1	2									2	1	3	1		2				2		2
175-179			3										2	1	2		3			1	1		
180-184		1	1									2		1	1		4			1			
185-189			2	1	3									1			4			2			
190-194			1	2												1	4				2		2
195-199			1	1								1					5						
200-204																	3				2		
205-209													1				2						
210-214																	2				2		
215-219												1					1				1	1	
220-224		1																					
225-229																							
230-234																	1						
235-239																	1						
240-244																							
245-249																							
250-254																				1			
TOTALS	7	30	537	11	14	13	4	1	26	488	2212	204	387	315	21	4	71	45	121	404	1149	806	1181

cavity between pelvic fins and anus visible through body wall; a row of melanophores extends from middle of base of anal fin along mid-ventral part of peduncle to procurrent rays of caudal fin; one large and two small melanophores on mid-dorsal part of caudal peduncle just anterior to procurrent rays of caudal fin; two deeply imbedded melanophores at anterior margin of hypural plate; two more on caudal fin just posterior to posterior margin of hypural plate; a few small melanophores are present on the upper procurrent rays of caudal fin; the middle rays of caudal fin have a scattering of small melanophores and the rest of the fin is clear; the anal, dorsal, pelvic, and pectoral fins are without pigment. Some pigment is present deep in otic region; a single melanophore on side of head just behind eye; a few melanophores are deeply imbedded along dorsal surface of vertebral column visible through lateral musculature.

The gut is composed of many alternate dark and light bands in the region posterior to the pelvic fins and other than the covering skin forms the ventral margin of the body. The artist who illustrated the two young menhaden on page 121, Kuntz and Radcliffe (1917), apparently errored with regard to the gut tract. I do not think the gut is a convoluted structure but instead a uniformly ringed tube. The dark rings probably represent thickened portions of the gut wall. The series of photographs illustrate the developments of the gut tract which is visible through the body wall of the smaller-sized individuals. Anal, caudal, and dorsal fins are composed of well-developed rays; pelvic fin rays somewhat filamentous and better developed than pectoral fin rays, the pectoral fin being composed of a relatively large, fleshy base with fine filamentous rays on posterior margin; lower margin of maxillary with 16 sharp-pointed serrations; no scales; myotomes plainly visible; lower jaw protrudes considerably; gill rakers 6 + 15 on first arch of left side; operculum not fully developed, *i.e.* does not entirely cover the gills, posterior elements exposed. Gill filaments progressively are better developd from anterior to the posterior arches; pseudobranchiae well developed, about the same length as posterior gill arch filaments.

19.2 mm. (TU 7129)—A double row of widely spaced melanophores is present on ventrolateral region between pectoral and pelvic fins, 8 on left, 9 on right; one centrally located melanophore on symphysis; one large chromatophore at base of pectoral fin; an irregular row of melanophores along dorsal part of body cavity, from region of pelvics to the anus; a row of three large melanophores, the anteriormost under the middle of base of anal fin, the middle one at the posterior end of the base of the anal and the posterior melanophores approximately equidistant from base of caudal fin and the posterior base of the anal; a row of four small melanophores near distal ends of posterior rays of anal fin; two deeply imbedded melanophores, one on the upper anterior margin of hypural plate and the other on the lower anterior margin; small to large-sized melanophores scattered on caudal fin, a concentration of melanophores on the lower posterior border; two melanophores are present on the median dorsal area of peduncle just anterior to the base of caudal fin; a single imbedded chromatophore exists at the occiput; the top of the head over the brain is unpigmented; there are no chromatophores on tip of snout. The pigment along the dorsal surface of the vertebral column is visible through the musculature of caudal peduncle. Dorsal, caudal, and anal fins are developed with membranes between rays; pelvic fins somewhat filamentous as in 18.9 mm. specimen. Pectoral fin with a relatively large fleshy base, rays are filamentous. Gut occupies most ventral part of body in the region extending from the insertion of the pelvic fins to the anus; 18 pointed serrations on lower margin of maxillary; gill rakers 5 + 14 on first arch of left side.

19.7 mm. (TU 7129)—There is a single large melanophore at the base of pectoral; several large melanophores on isthmus; a double row of large melanophores along ventrolateral region between insertion of pectorals and pelvics; a single large melanophore on side of head just posterior to the eye; some pigmentation internal in the otic region; pectoral, pelvic, and dorsal fins devoid of pigment; a row of melanophores exists on the posterior rays of anal fin; the pigmentation of the dorsal part of body cavity between insertion of pelvic fins and anus is visible through body wall; a continuous row of melanophores present between middle of base of anal fin and lower procurrent rays of caudal fin; several large melanophores along anterior margin of hypural plate and two patches, an upper and a lower, along posterior margin of same plate; a scattering of small melanophores along rays of caudal fin; a row of deeply imbedded melanophores on dorsal surface of vertebral column in peduncular region. Three melanophores present on dorsal aspect of caudal peduncle just anterior to procurrent rays of caudal fin; two deeply imbedded melanophores in occipital region, no other pigmentation on dorsal aspect of head.

The serrations on lower border of left and right maxillary are 17-17 in number respectively; 16 gill rakers on lower limb, first arch of left side. The gut forms the ventral margin of body between pelvic fins and anus. No ventral scutes; no scales.

20.0 mm. (TU 7129)—The pigmentation is similar to that described for the 19.7 mm. individual.

The gut forms the ventral mragin of body as described for above larvae; 16-16 serrations on ventral border of maxillaries; 17 gill rakers on lower limb of anterior left arch; anal, dorsal, and caudal fins similar in stage of development as described above for 19.7 mm. specimen; pelvic fin rays not so filamentous as on smaller individuals and connected by membranous tissue; pectoral fins rudimentary with relatively large fleshy base, posterior margin of fleshy base with filamentous rays; operculum nearly extending to anterior margin of cleithrum; no scales; no ventral scutes.

20.4 mm. (TU 7129)—The pigmentation is similar to that described for the 19.7 mm. specimen except for the following modifications: There are two melanophores at the base of each pectoral fin, the assumed additional one is smaller and more dorsal in position; the row of melanophores at base of anal fin to lower procurrent rays of caudal fin extends to anterior third of base; the row of melanophores on anal fin rays is slightly more extensive; the caudal fin more heavily pigmented. There is a single melanophore on dorsal aspect of head over the brain.

Development of fins is about the same as described for 20.0 mm. specimen; 17-19 serrations on ventral border of maxillaries; no scales; no ventral scutes; gut forms ventral margin of body; gill-raker count not determined.

21.0 mm. (TU 7129)—There are two melanophores at the base of each pectoral fin; posterior two-thirds of ''ventrolateral'' rows of melanophores lateral rather than ventrolateral in position; in addition there is a scattering of small melanophores (7) on the surface of the anterior part of the gut tract; two large melanophores on isthmus; two melanophores on side of head behind eye. The melanophore on dorsal part of lining of body cavity is still prominent; row of melanophores along base of anal fin and ventral margin of peduncle more extensive than in previously described individual; row of melanophores on anal fin extend along entire length of fin; pigmentation around hypural plate similar to that described for the 19.7 mm. specimen; the basal three-quarters of caudal fin quite heavily speckled with melanophores; dorsal fin with a narrow band of small melanophores mid-way out on rays; pelvic and pectoral fins devoid of pigment. The median dorsal region of caudal peduncle has melanophores extending from procurrent rays of caudal fin halfway to posterior part of base of dorsal fin; two deeply-imbedded and two superficial melanophores in occipital region; five melanophores on dorsal part of head over brain; several melanophores on tip of snout and a few on tip of lower jaw.

Ringed portion of gut tract extends anterior to insertion of pelvics but forms ventral margin of body; 18-19 serrations on ventral margin of maxillaries; no scales; no ventral scutes; operculum extends to cleithrum thus covering the gills. Pectoral fins have fleshy base, the rays are not so filamentous and are somewhat connected by membranous tissue.

22.3 mm. (TU 7129)—The pigmentary differences in comparison with the 21.3 mm. individual are as follows: More of the "ventrolateral" melanophores are found in a lateral position; fewer small melanophores (4) on lateral surface of anterior part of gut. The pigmentation at base of anal fin, on anal and caudal fins, and on both upper and lower surfaces of peduncle about the same as that described for 21.3 mm. specimen; less pigmentation on dorsal fin than given for previous specimen, actually only a few melanophores on central rays; pigmentation of head similar to that described for 21.3 mm. individual.

The gut forms ventral margin but is not ringed anterior to the insertion of pelvics; 19-18 serrations on ventral margin of maxillaries; 12 + 23 gill rakers on first arch, left side; no scales; basal elements of ventral scutes visible in region between pectoral and pelvic fins, no protruding spines.

22.4 mm. (TU 7129)—In general there is considerably more pigmentation than described for the 22.3 mm. specimen. The dorsal, anal, and caudal fin rays are densely pigmented; the pigmentation on dorsal aspect of caudal peduncle continues to dorsal fin base; also there are scattered melanophores along base of dorsal fin. The pigmentation at the base of pectorals, lateral region of anterior part of gut, isthmus, side of head posterior to eye, at tip of snout and chin, and dorsal part of body lining is like that described for the 21.3 mm. specimen. The top of the head over the brain is speckled with melanophores.

The posterior third of the gut tract forms the ventral margin of body whereas the anterior two-thirds has taken a more dorsal position leaving a space between itself and the ventral body wall; articulations are visible along the pelvic fin rays; rays of pectoral fin are very slender, fleshy fin base; basal (internal) elements of ventral scutes developed, six posterior to insertion of pelvics as well as 12 anterior to pelvics. The scutes apparently develop progressively posteriorly, *i.e.* start developing in the anterior region first and gradually develop posteriorly to the anal region; no scute-spines are visible; 13 + 25 gill rakers on first, left arch; 19-19 serrations on ventral margin of maxillaries; no scales.

23.7 mm. (TU 7129)—The following are the pigmentary changes from the pattern described for the 22.4 mm. specimen. The top of the head, side of head behind eye, lateral surface of anterior gut are more densely pigmented. A single melanophore is present on the ventral margin of orbit.

The gut is nearly removed from contact with ventral body wall; 18-17 serrations on ventral margin of maxillaries; no scales. Pectoral rays are thicker. Eleven basal elements of ventral scutes are present posterior to the insertion of pelvics; projecting spines on a few anterior basal elements.

24.2 mm. (TU 7129)—Pigmentation is more extensive than described for the 23.7 mm. individual. Melanophores extend along entire base of anal fin; several small melanophores on ventral body wall just anterior to anus; lateral aspect of anterior gut heavily pigmented; four large melanophores on side of head posterior to eye; four melanophores on ventral rim of orbit; dorsal surface of head over brain more heavily pigmented; pigmentation of tip of chin and snout more extensive; one melanophore on middle of snout.

There is less pigmentation on isthmus and none on ventral area between bases of pectoral fins.

Pectoral fin rays are better developed, fleshy base reduced in size. Twelve basal elements of ventral scutes are developed posterior to the insertion of pelvics as well as twelve developed anteriorly. Prominent spines projecting from the twelve basal elements anterior to the pelvic fins; 17-18 serrations on ventral border of maxillaries; no scales.

24.7 mm. (TU 7129)—The pigmentation is the same as that given for the 24.2 mm. specimen except that one melanophore is present on ventral region between bases of pectoral fins; no melanophores on ventral margin anterior to anus. The row of melanophores on side of head behind eye is continuous with the melanophores on ventral rim of orbit; more pigmentation on chin and tip of snout; scattered melanophores on mid-region of snout; a small patch of melanophores posterior to occiput; fins perhaps a little more densely pigmented.

Ventral scutes in about the same state of development as described for the 24.2 mm. individual; 13-15 serrations on ventral border of maxillaries; no scales.

25.5 mm. (TU 8109)—Body wall is opaque; however, pigmentation of anterior gut shows through as a darkened area; top of head over brain heavily pigmented; anterior half of snout pigmented as well as chin; patch on side of head and ventral rim of orbit more extensive than described for the 24.7 mm. specimen; the dense row of melanophores along base of dorsal fin is continuous on the predorsal median region to the occipital patch; the postdorsal median pigmentation forms a stripe.

Pectoral fins without fleshy base; 10 ventral scute spines present posterior to the insertion of the pelvic fins; 18-18 serrations on ventral margin of maxillaries; no scales; a single stria developed on operculum.

26.8 mm. (TU 8109)—Pigmentation extends down on dorsal lateral area along anterior part of body; pigmentation of top of head continuous with pigmentation on side of head and rim of orbit, also continuous down snout to the patch at the tip. No pigment present on isthmus or between bases of pectorals.

Four striae present on left operculum; twelve ventral scutes with spines posterior to pelvics; serrations present on maxillaries; scales present.

27.7 mm. and 28.2 mm. (TU 8109)—There are six striae on left operculum; serrations present on ventral border of maxillaries; posterior margin of scales smooth.

40.3 mm. (TU 9671)—The left operculum has 11 striae; 3 blunt serrations on ventral border of maxillaries; scales with blunt projections on posterior border, *i.e.* the beginning of the development of the pectinations.

58.4 mm. (TU 9255)—Eleven striae present on left operculum; only a slight roughness on posterior part of ventral margin of maxillary, no serrations.

PROPORTIONAL MEASUREMENTS

The following is the list of material (total of 134 specimens) upon which the measurements were made. The proportional measurements are shown in Figures 1-8. All the specimens were obtained from Lake Pontchartrain, Louisiana and the number in parentheses which follows the catalog number designates only the number of specimens used and usually not the number contained in the series.

TU 9630 (11), lat 30°10′N, long 89°54′W, 17 Feb. 1955; TU 9609 (8), lat 30°16′N, long 90°16′W, 31 Mar. 1955; TU 9678 (12), lat 30°10′N, long 89°54′W, 6 May 1955; TU 9415 (7), lat 30°10′N, long 89°55′W, 5 Nov. 1954; TU 10748 (24), lat 30°02′N, long 90°14′W, 26 July 1954; TU 9671 (12), lat 30°03′N, long 90°14′W, 13 May 1955; TU 9454 (12), lat 30°10′N, long 87°55′W, 5 Nov. 1954; TU 6687 (10), lat 30°03′N, long 90°14′W, 15 Sept. 1953; TU 9255 (10), lat 30°9′N, long 90°01′W, 16 Aug. 1954; TU 7125 (2), lat 30°08′N, long 89°51′W, 19 Jan. 1954; TU 8109 (8), lat 30°08′N, long 89°52′W, 7 Feb. 1954; TU 8758 (8), lat 30°06′N, long 90°16′W, 19 Apr. 1954; and TU 7129 (10), lat 30°11′N, long 89°54′W, 19 Jan. 1954.

During the first year of the menhaden study the author became interested in the profound changes in the body shape during the development and transformation of larval to young stages and this eventually led to an analysis of proportional measurements. Twenty different measurements were made on each specimen and these figures were converted to percentages in thousands of standard length, and are presented in graphical form. Four series of measurements (body depth, pectoral-to-pelvic insertion, upper jaw length, and snout length) were also plotted using original units (Figure 8). This latter method of presentation does not accentuate the differential growth of parts and regions of body as much as does the percentage method (Figures 1-7). The growth of most of the parts and regions of body seem to be closely correlated with the increase in standard length, *i.e.* after the transformation period has been passed. The transformation period apparently terminates when the fish has reached 28 to 30 mm. in standard length.

Specimens used by Hildebrand (1948) ranged in standard length from 45 to 207 mm. and thus he did not give measurements for specimens in the transformation stage. Seventeen of the parts and dis-

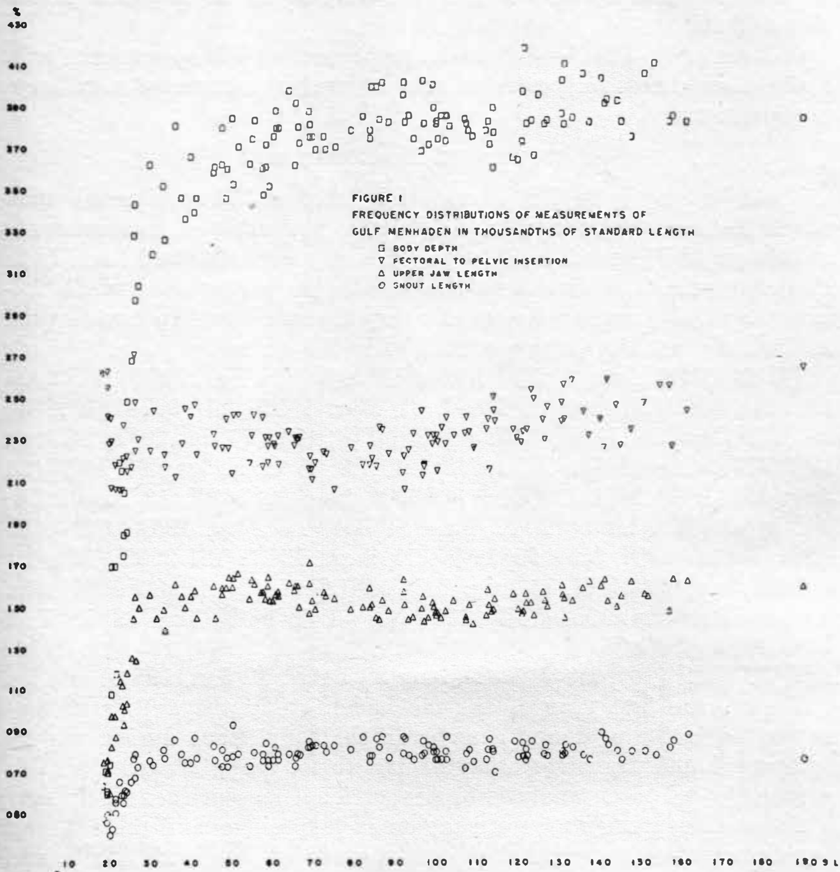

FIGURE 1
FREQUENCY DISTRIBUTIONS OF MEASUREMENTS OF GULF MENHADEN IN THOUSANDTHS OF STANDARD LENGTH

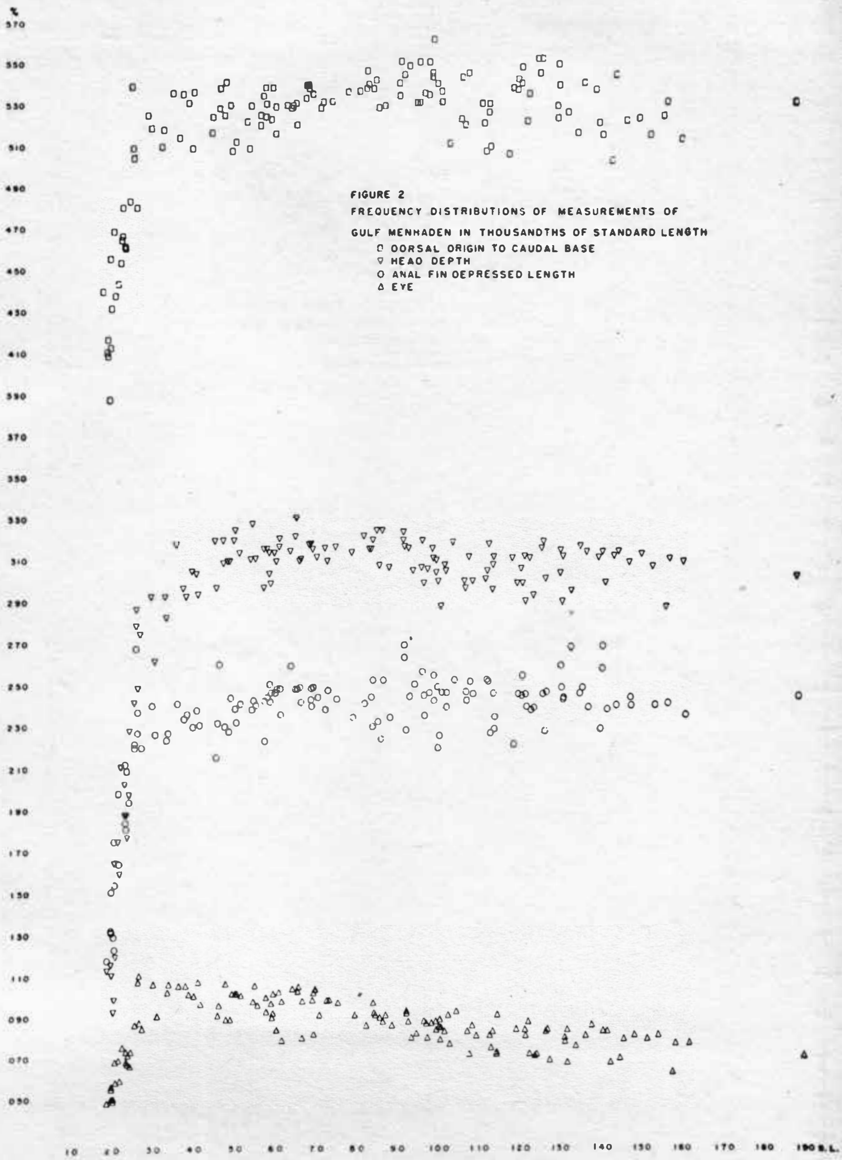

FIGURE 2
FREQUENCY DISTRIBUTIONS OF MEASUREMENTS OF GULF MENHADEN IN THOUSANDTHS OF STANDARD LENGTH
□ DORSAL ORIGIN TO CAUDAL BASE
▽ HEAD DEPTH
○ ANAL FIN DEPRESSED LENGTH
△ EYE

tances increased more rapidly in dimensions than the standard length during the transformation period. In other words, differential growth is characteristic of the transformation period whereas the growth of parts is closely correlated (consistently proportional) to the growth in length during the post-transformation period. The dorsal origin-to-occiput and dorsal origin-to-snout increase in dimension at a slower

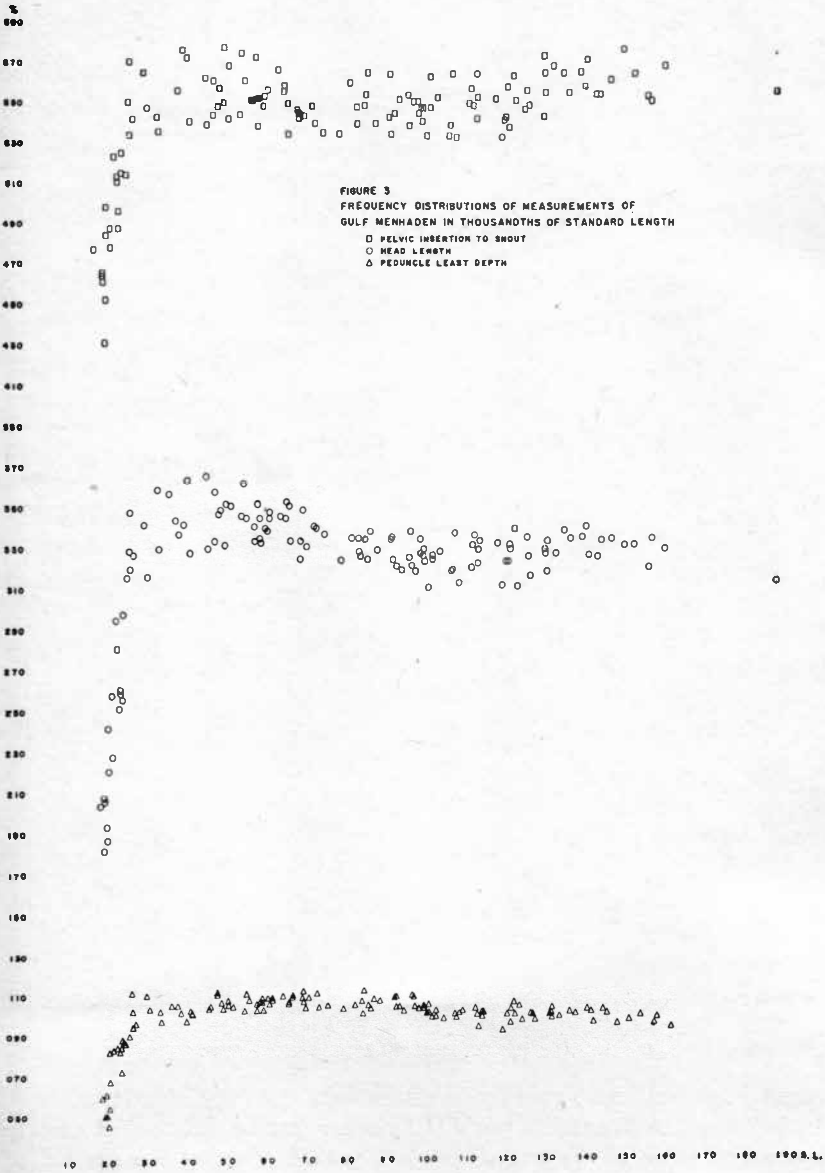

FIGURE 3
FREQUENCY DISTRIBUTIONS OF MEASUREMENTS OF GULF MENHADEN IN THOUSANDTHS OF STANDARD LENGTH

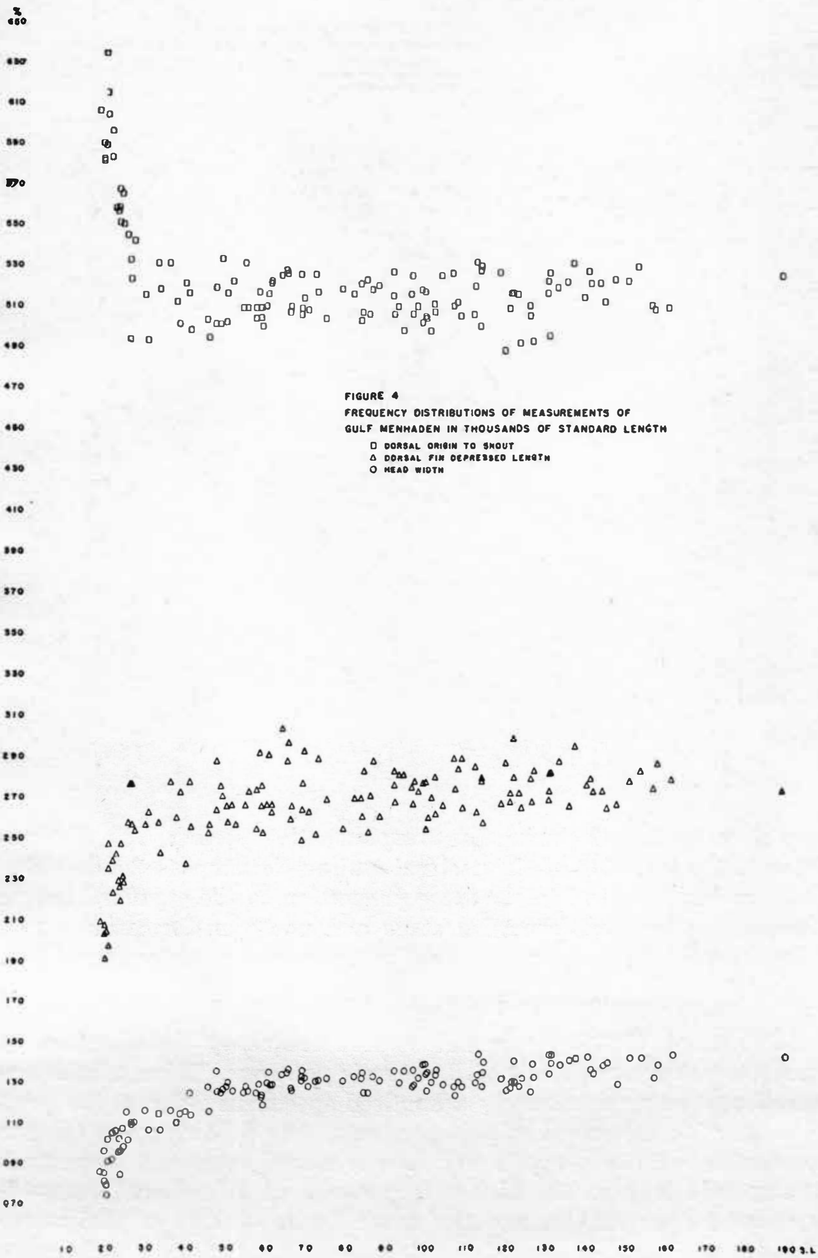

FIGURE 4
FREQUENCY DISTRIBUTIONS OF MEASUREMENTS OF GULF MENHADEN IN THOUSANDS OF STANDARD LENGTH

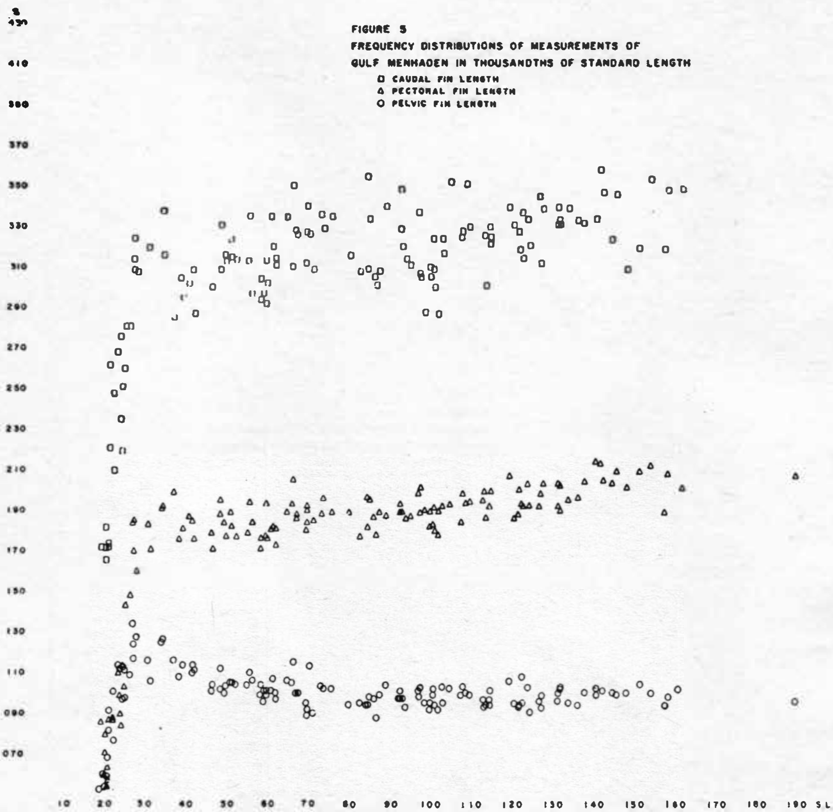

FIGURE 5
FREQUENCY DISTRIBUTIONS OF MEASUREMENTS OF GULF MENHADEN IN THOUSANDTHS OF STANDARD LENGTH

rate than the length during the transformation period. The distance between the insertion of the pectoral and pelvic fins was the only distance which remained in the same proportion to the standard length throughout the transformation stage and post-transformation stage. Obviously the fin positions are fixed early in embryonic or larval life.

MERISTIC COUNTS

Hildebrand (1948) presented several frequency distributions of proportional measurements of *Brevoortia patronus*. These tabulations were based on approximately a hundred specimens whereas the present study is a treatment of 134 specimens. The following is a tabular comparison of the proportional measurements expressed in percent of standard length. The higher frequencies of Hildebrand's data is enclosed in parentheses and the range limits outside of the parentheses:

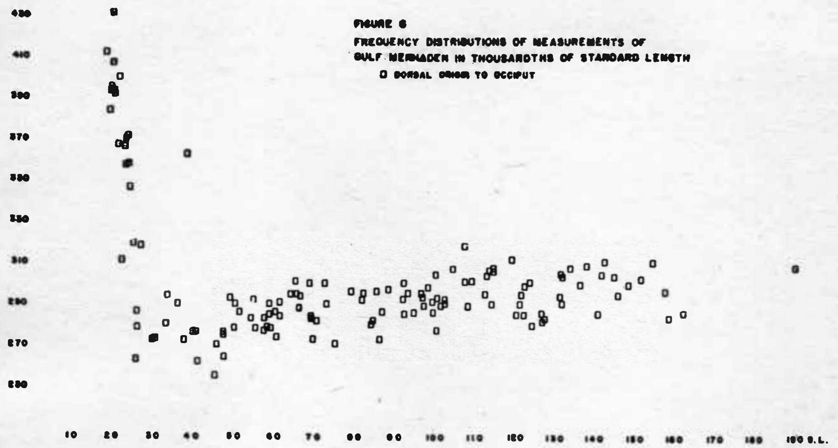

FIGURE 6
FREQUENCY DISTRIBUTIONS OF MEASUREMENTS OF GULF MENHADEN IN THOUSANDTHS OF STANDARD LENGTH
□ DORSAL ORIGIN TO OCCIPUT

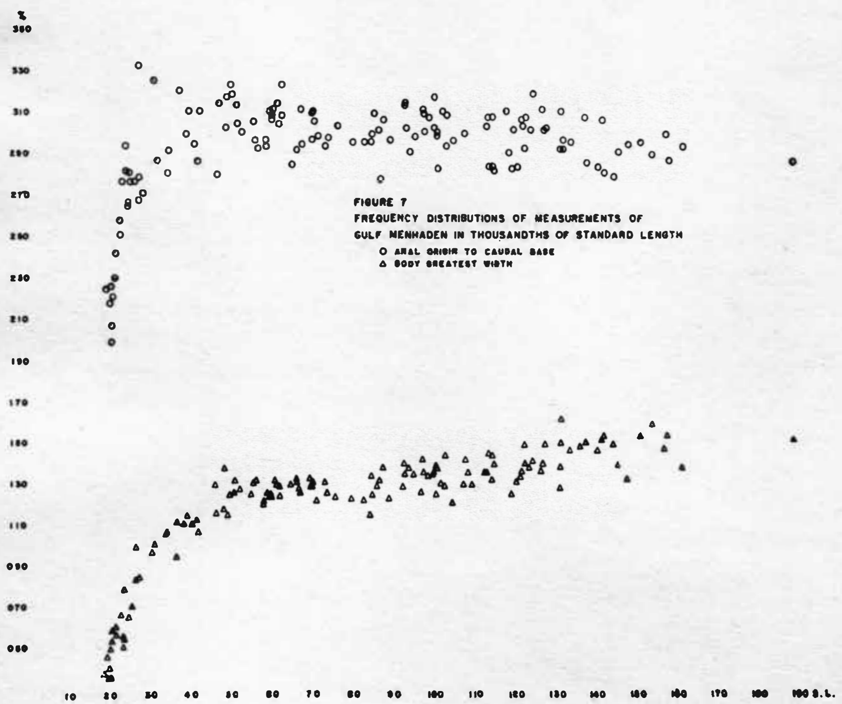

FIGURE 7
FREQUENCY DISTRIBUTIONS OF MEASUREMENTS OF GULF MENHADEN IN THOUSANDTHS OF STANDARD LENGTH
○ ANAL ORIGIN TO CAUDAL BASE
△ BODY GREATEST WIDTH


FIGURE 8
FREQUENCY DISTRIBUTION OF MEASUREMENTS OF GULF MENHADEN
BODY DEPTH
PECTORAL TO PELVIC INSERTION
UPPER JAW LENGTH
SNOUT LENGTH
MM.
S.L.

	Hildebrand	Lake Pontchartrain
Depth of head	29(31-35) 37	29-33
Length of head	31(32-35) 38	31-37
Body depth	33(37-42) 45	33-41
Maxillary length (upper jaw length)	14(15-16) 17.5	14-16
Caudal fin length (lower lobe)	31(33-36) 39	29-35
Pectoral fin length	19(20-22) 23	17-21

The percentage figures for Lake Pontchartrain material are estimations made by inspection of Figures 1-7 and approximate the range limits. The data for the transformation period is not included. It is interesting to note that the Pontchartrain material falls at the lower end of the range for each character given by Hildebrand. Also the variability is less for the Pontchartrain material which is as one would expect when all samples are taken from the same area versus samples taken from over entire range of a relatively wide ranging species.

The serrations on the ventral border of the maxillaries were not mentioned by Hildebrand (1948) nor by Kuntz and Radcliffe (1917). The number of serrations are given above in the descriptions. These structures disappear with age (size) as indicated above. The number of gill rakers and striae on the operculum increases with age (size). The latter character may have an upper limit in number; however, the gill rakers seem to continue to increase in number (Hildebrand, 1948) from 15 on lower arch in 18.9 mm. specimen to 150 plus in 200 mm. specimens.

RELATIVE ABUNDANCE AND MASS MOVEMENTS

The catch records were tabulated and are presented in Table 1 as a length-frequency distribution. The higher frequencies in most cases represent only a part of the catch. Large catches were made in June, July, August, and September, but only a sample was measured. Thus the break in relative numbers between September and October, 1953, and August and September, 1954, would be more pronounced if all the specimens caught had been included. The moderate frequency of occurrences of menhaden in the lake in November of 1954 was possibly the result of relatively high salinity for Lake Pontchartrain (18 to 20 parts per thousand) which prevailed during easterly and southeasterly winds. The emigration of the zero year class individuals from the estuarine waters seems to be during August or September. Additional data may show that menhaden sometimes may not leave the estuarine areas until October or even later. This time of emigration corresponds with that given by Westman and Nigrelli (1955) for *Brevoortia tyrannus* in the New York and New Jersey area. The emigration of menhaden from Lake Pontchartrain each fall is more complete than that reported by Suttkus (1954) for the Atlantic croaker.

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DISCUSSION

MODERATOR PRITCHARD: Before I comment directly on this paper, I would like to advise the audience that my field of specialization is not biology of the organisms living in the coastal environment, but rather, the physical and chemical properties of that makeup which constitutes the makeup for the organism, so that in listening to this paper, the thing that struck me as interesting was the problem or the statement that none of the menhaden apparently spawn in the lake, but come in from outside.

Also, that statement that the small larvae apparently are able to remain within the region against the tidal currents within the region studied. Without trying to fit an explanation of this movement and remaining in the region, without knowing much about the hydrography of this particular area, I would, however, like to comment on another situation which may have some bearing.

In the Chesapeake Bay, the croaker spawn off the mouth of the Bay out in the ocean and are brought as larvae forms some 140 miles up the Bay in about the same period as the menhaden larvae come into Lake Ponchartrain. These young fish are in larvae form and we do not believe have the ability to make a direct migration of this distance. They are randomly searching for food and trying to stay vertically within an environment of temperature and salinity.

However, we know the introduction of fresh water into an estuary region sets up a circulatory pattern that involves both inflows and outflows. In the Chesapeake Bay area it is a vertical pattern, and these young larval croakers are found in the deeper water and are apparently carried up from the spawning grounds in the mouth of the Bay to the upper Bay simply by the movement of these waters and from the estimate of the age of the youngest larva caught compared to our own observations of the rate of movement, of the deeper movement, indicates the fish arrived at the upper part of the Bay at about the time that an inanimate object would be carried up by the return flow. Did you make any effort to consider what mechanism might bring the larva into the lake?

MR. SUTTKUS: I have studied the croaker in the Lake Ponchartrain area also, and I agree with Wallace's report on the Chesapeake Bay larvae. He cited the current data that Cowells gave for that area. However, the croaker is more of a bottom form and the menhaden is a surface form, and I have observed these things swimming in current that we could hardly make headway against, pulling a trawl with a clinker type Lyman boat, but these small fishes don't seem to have any trouble combating the current. It must be the streamlining, but they can exist in the current.

Possibly the movement into the inside water is a passive one; they do come in with the passing current. But, I don't think they seek the eddy areas.

MODERATOR PRITCHARD: Well, how do they know which way the current is going unless they are near enough to a reference surface such as the bottom? We are moving right now at a thousand miles a minute as far as the rotation of the earth goes, and we are not conscious of it. Is there any discussion?

MR. VIOSCA [New Orleans, Louisiana]: I was following the movement of the white shrimp from the Mississippi sound into Lake Vaughn and a storm came into the pitcure and the young size class that was about an inch to an inch and a half long, was moved 50 miles by the one storm alone, which I think is a passive movement. Usually they move a thousand feet to a mile a day. So, that might have a bearing on that sort of thing.

MODERATOR PRITCHARD: Thank you.

MR. GUNTER [Gulf Coast Research Laboratory, Ocean Springs, Mississippi]. I wanted to say that Pearson commented on this inward movement of the croaker on the Texas Coast years ago and he said that the grim determination with which these small fish headed into the current was a marvelous thing to see.

Now, another question that came to mind is, how such things as shrimp come in from five and possibly ten miles offshore when they are larvae, quite different from the fish and absolutely helpless? They can't buck the current at all.

Some years ago, a man did some work at our laboratory and said there was a cloud of eggs and larvae offshore and that they came into the little narrow pass and made their way into the bay. Well, all the current charts showed that the current is heading to the south at a considerable rate. Either there is something wrong with our knowledge of currents or there is something that we don't know anything about. The hydrographers will have to work with the biologists to solve those problems.

Certainly the movement of the shrimp, when you compare their minute size, is something like that of the salmon coming from great distances to its home stream.

ECOLOGICAL CHANGES AFFECTING THE PRODUCTIVITY OF OYSTER GROUNDS

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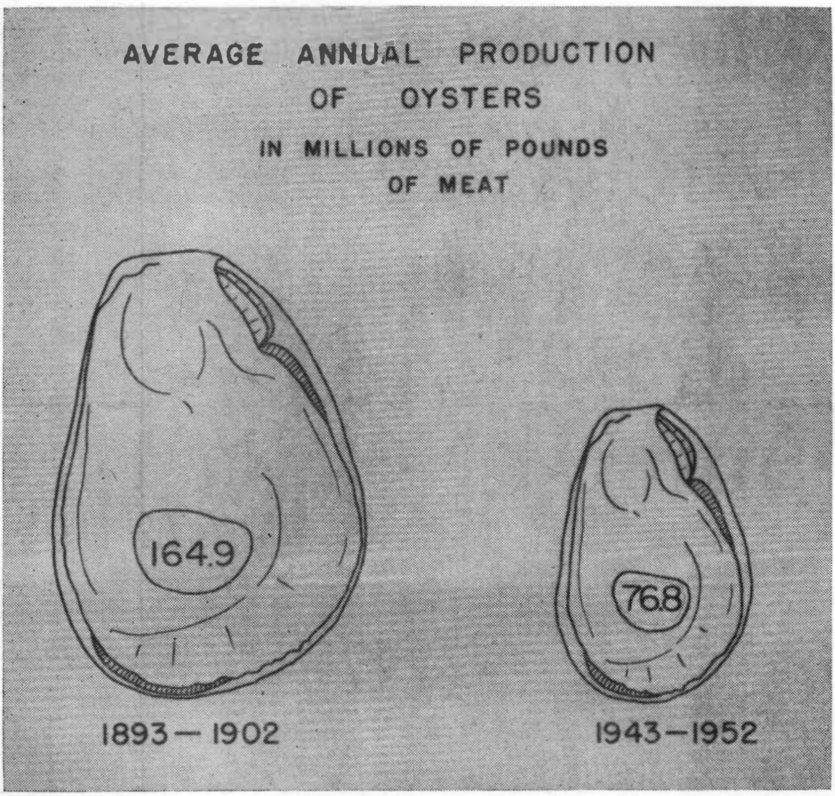
Among the edible mollusks in the United States, the oyster occupies a prominent position. According to the latest statistical summary of the Fish and Wildlife Service, 82.2 million pounds of oyster meat were consumed in 1952 as compared with 39.8 million pounds of meat of various clams. Today the oyster fishery continues to be a profitable business bringing a total annual revenue of about 32 million dollars to the oyster farmers and fishermen, but it is not in a thriving condition. The industry experiences a steady decline and during the last half a century has decreased to about one half of its former volume. This decline can be clearly seen by comparing the

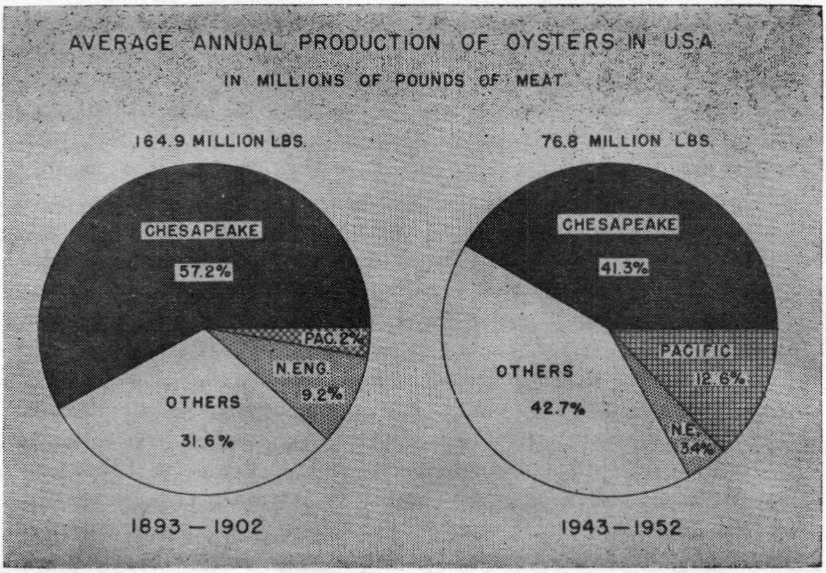


average annual production for the decades of 1893-1902 with that for 1943-1952. The diagram in Figure 1 shows graphically that an annual average of 164.9 million pounds of meat during the decade of 1893-1902 has shrunk to the present low level of 76.8 million pounds (1943-1952). It is true that the statistical data for the earlier periods are not too accurate but there is no doubt that the difference in the figures of production far exceeds the possible errors in the data.

A comparison of the yield of oysters by the principal oyster producing areas may give us some ideas about the probable causes of decline. The Chesapeake Bay with its quarter of a million acres of potentially productive oyster bottoms is the richest oyster producing body of water in the world. At the beginning of this century about 57 per cent of oysters produced in the U. S. A. were taken from the Bay. At present the Bay yields only about one third of the amount of oyster meat it used to produce 50 years ago, and its contribution of the total harvest of oysters constitutes only 41 per cent. Likewise, the New England States, where oyster farming has thrived since its introduction in this country nearly a century ago, contribute only 2.6 million pounds against the 15.1 million pounds produced annually during the decade of 1893-1902. The importance of the New England States in terms of percentage of oyster production in the country dropped from 9.2 to 3.4 per cent. At the same time the oyster production of the Pacific States shows a substantial increase from 3.3 million pounds to 9.6 million pounds and the gain from 2 to 12.6 per cent of the total catch. All these changes are graphically presented in Figure 2.

The three above mentioned major regions of oyster production represent the areas in which three different methods of raising and harvesting of oysters are practiced. The Chesapeake Bay comprises large areas of public oyster grounds or so-called natural rocks from which oysters may be harvested by the citizens of the states upon paying a nominal fee. Oyster cultivation is not practiced except on a rather small area of privately leased grounds. State governments regulate the harvesting of oysters by prohibiting power dredging in certain areas which are restricted to tongers by declaring closed seasons and enforcing the minimum size and cull laws. As a program of state management of oyster grounds, shells are being planted on various bars though these operations are limited in scope and are in general ineffective. As a whole the major part of public rocks has been overexploited by years of careless dredging and many of them have been depleted beyond recovery.

As a contrast, the harvesting of oysters from public grounds is insignificant in New England, the industry in these states depending



on rational exploitation and cultivation of privately leased or owned beds. Oyster farming, or oyster culture as it is practiced in Connecticut, Rhode Island, and Massachusetts, consists of several distinct operations: planting of shells to obtain seed oysters, rebedding them several times to provide sufficient space for their growth; controlling the enemies; fattening and conditioning fully grown oysters; harvesting, washing, and grading for shipment.

The oyster industry of the Pacific Coast uses an entirely different method. The production of oysters in these states is based on the introduced species of Japanese oyster, *Crassostrea gigas.* The industry makes no serious attempt to produce the seed of this species locally, but prefers to import seed oysters from Japan and plant them in local waters. The production of seed, its packing and shipment are supervised by the representative of the Pacific Oyster Growers Association who is detailed annually to Japan for this purpose. Spectacular success of the Pacific oyster industry is due to two major factors: availability of needed quantity of seed at a price which is less than the cost of production of seed in American waters, and the fact that bottoms originally selected for planting were not occupied by native shellfish. The Pacific Coast oyster industry introduced a foreign species of mollusk into an area which heretofore was nonproductive and began to utilize barren bottoms. This situation was the principal reason for the rapid success of the West Coast fishery.

The total acreage of oyster producing grounds in the U. S. A. has never been recorded with accuracy. In 1940, I made a tabulation listing from various sources available to me all the areas indicated on maps as natural oyster bottoms, or oyster rocks. The total amounted to 1.2 million acres. In addition to this area, 186,000 acres were recorded as privately owned or leased bottoms suitable for oyster farming. If we assume that the average yield of one bushel of oysters is equal to 5 pounds of oyster meat the production of 82 million pounds in 1952 may be equivalent to 16.4 million bushels of marketable oysters. If we consider further that the average productivity of oyster bottom is only 100 bushels per year, we arrive at the estimate of 164,000 acres as an area sufficient to produce the present annual harvest of oysters. The conclusion seems to be inevitable that only a small fraction of the total acreage of oyster bottom is at present productive.

Before discussing the reasons for the decline of the annual catch, we shall consider briefly the biological characteristics of the oyster and of its environment. The principal species, *Crassostrea virginica,* commonly called Atlantic or Eastern oyster, is a highly adaptable organism which tolerates without suffering injury wide fluctuations of the temperature and salinity of water. The eastern oyster thrives equally well on semisoft and on hard bottoms. At the latitudes where winter temperatures do not fall below the freezing point of sea water it can be found growing within a tidal zone periodically exposed to air and sun. In more northern latitudes it cannot survive the winter freeze and consequently grows only below the low water mark on bottoms which are never exposed at low tide. Commercially exploited grounds are not found beyond the depth of about 40 feet although individual oysters were taken from much deeper waters.

Geographical distribution of the Atlantic oyster covers a broad range from 45° to 25° Latitude North and indicates the adaptability of this species to great climatic differences. There is a possibility, of course, that within the area of distribution there are several geographical races or subspecies of *C. virginica* adapted to more narrow climatic conditions. This suggestion was made by several authors, but the existence of races has not been finally established.

The tolerance of this euryhaline organism to the changes in the concentrations of salt in the sea water likewise extends over a wide range from about 4 to 32 parts per thousand. In its periodically changing and generally unstable estuarine environment the Atlantic oyster forms banks or reefs which stretch over thousands of square miles along the shores. They consist of millions of individuals of various sizes and ages which crowd themselves and frequently grow in compact clusters.

Different conditions of the environment leave their impact on the shape and size of the oyster. The morphology of this mollusk is so flexible that its shell characteristics are of little value to the taxonomist trying to identify the species. Some generalizations can be made, however, from an examination of a large collection of individuals taken over the entire area of distribution. As a rule, wide and well sculptured shells of hard material are found in the oysters grown singly on firm bottom, while long and narrow shells without any sculptured embellishments are typical for the specimen found on soft, muddy bottoms upon which the oysters often grow in a vertical position. Likewise, oysters growing in clusters are usually very long and narrow while single specimens living on hard bottoms grow in width as much as in length, and consequently are round shaped.

The abundance of wild populations of oysters and the extent of areas occupied by oyster beds are unquestionably the signs of the success of the species in its competition with other sedentary invertebrates for space and food. Several physiological characteristics of *Crassostrea virginica* are definitely advantageous in its strife for existence. The first to be mentioned is the great fecundity of the oyster. Actual counts show that large females of the species *C. virginica* and *C. gigas* discharge in one shedding tens of millions of eggs and repeat the process several times during one spawning period. The presence of oyster sperm in the water stimulates the spawning of a ripe female which discharges its eggs through the gills, and by violent snapping of the valves disperse them in the surrounding water. These physiological adaptations tend to enhance the chance for fertilization of eggs which being heavier than water sink to the bottom. The cleavage is rapid; within a few hours after fertilization a free swimming larva emerges from the egg and swims toward the surface. In this way the larva escapes the danger of being smothered by sediments on the bottom.

Feeding of the oyster is a continuous process which consists of straining large quantities of water propelled by the gills. The organism is equipped with a highly complex mechanism for adjusting the rate of flow of water through the gills according to its needs. A certain degree of selection of food according to the size, shape and nature of microscopic organisms upon which the oyster feeds is accomplished by the ciliated cells of the gills and by the labial palps.

The powerful adductor muscle is capable hermetically to close the valves of the oyster and to remain in a closed condition for days and even weeks without expending energy. This ability to separate itself from the outside environment is a remarkable safety device which is used by the oyster as a defense reaction against the attack of enemies and is also employed as protection against harmful effects of poisons that may be accidentally present in coastal waters.

Invasion of shell material by various infiltrating and boring algae, sponges, and clams (*Martesia*) is counteracted by deposition of organic substance, conchiolin, which rapidly becomes calcified over the area of invasion. Although in a process of evolution, the oyster lost its power of locomotion, it has not become an entirely defenseless organism. As a matter of fact, highly developed chemical sense and sensitivity to changes in illumination and to vibrations of water keep the oyster aware of the approaching danger and convey the warning signal to the adductor muscle.

The principal enemies against which the oyster has no defense are human beings who devastate the entire oyster communities by harvesting them with powerful mechanical devices; starfish which learned the trick of opening the shell by pulling it apart; various boring snails and conchs which with persistency and determination bore through the hard shell material and devour the meat; and several species of fishes (drum, skates) capable of crushing the shells with their powerful teeth.

The weakest phase in the life history of the oyster is its larval period when a small, free swimming creature emerges from a fertilized egg and drifts back and forth with tides and currents. Billions of oyster larvae perish during this period which lasts from two to three weeks. Some of them are devoured by other animals, others are carried away to the open ocean never to be returned by the incoming flood, and many perish because of disease, infection or lack of proper food. In the northern waters, where the spawning period is limited to a few weeks of the summer incidents of their sudden disappearance are frequent. Their survival may be easily affected by changes in the water such as sudden discharge of toxic industrial wastes, or by increased inflow of fresh water which results in a more effective flushing of estuaries. Increased ebb flow due to high river stage carries away larger than normal percentage of larvae which perish in the open sea. There may be an indirect effect due to the disappearance of extremely small naked flagellates and various microorganisms upon which the larvae feed. Our knowledge concerning the food requirements of the oyster larvae and their tolerances to the contamination of water are, however, not sufficient to identify the causes of their frequent failure to complete the development.

Study of the present conditions of the natural oyster bottoms provide no evidence that *C. virginica* became less effective in its struggle for existence with other competitors. Within the thriving oyster beds the numerical relationship among the populations of oysters and of various mussels (*Mytilus, Brachidontes, Volsella*), jingle shell (*Anomia*) and other sedentary invertebrates which complete with them is probably the same as they had been thousands of years ago. Likewise, there is no indication of the invasion of oyster grounds by some new enemies and parasites. It is true that the list of known predators, parasites, and commensals of the oyster increases almost every year by the addition of new names of animals heretofore not suspected to be harmful to oysters, but this increase only reflects the results of more extensive biological studies of oyster ecology. The newly listed enemies of the oyster were probably always associated with oyster populations. Likewise, there is no reason to believe that in the recent years they became more destructive than they were in the past. The only exception known to me is the Japanese conch, *Tritonalia japonica,* introduced about 50 years ago into the waters of the Pacific Coast with the first shipments of Japanese seed. This snail was first found by me in the waters of Puget Sound in 1928. Since this time and with the increased importation of Japanese seed it so firmly established itself in the new environment that it became a serious pest the control of which represents serious difficulty.

Principal changes which account for the decrease in oyster production in the United States are associated with the growth of human population and the accompanying industrialization of the country. The pollution of our water resources keeps pace with this growth. There are three types of pollution: agricultural, municipal, and industrial. Agricultural pollution consists mainly of soil washed from farm lands and deposited in the form of silt in natural water basins. Its beginning can be traced to the earliest day of the development of this country. The evidence of soil erosion was apparent to the keen observers of nature more than a century and a half ago. Thus, Tallman in 1800 in his "Essay on Tobacco" referred to "the constant sullage from the plough" which impeded the navigation in the James River, Virginia. Poor agricultural practices greatly increased the rate of soil erosion. It has been estimated that the Mississippi River alone carries annually about 7,000 million cubic feet of suspended matter washed from land and deposits this material in its delta and adjacent parts of the Gulf. A glance at the map of the Chesapeake Bay suggests that shallow areas along the shores are the places of accumulation of silt. A similar picture may be seen in San Francisco Bay and in many other bodies of water of the coastal areas of the United States. The most spectacular effect of silting is found in Texas coastal waters where certain bays during the last few years became almost completely filled with silt and sediments. For instance, the Colorado River has filled in more than 6,000 acres of upper Matagorda Bay and covered under its deposits some formerly productive reefs. Similar changes may be found in the West Bay (eastern branch of Matagorda Bay) where oyster-producing reefs described in 1904 by H. F. Moore and resurveyed in 1925 by Galtsoff are now covered with several feet of hardened mud which extends across the bay above the level of the water. In the delta of the Mississippi River the dredging of channels for navigation produced in many places considerable changes in the salinity regime of the area. The diversion of currents has made some of the grounds unsuitable to support the oyster populations because of the excess of fresh water, while other formerly unproductive bottoms now receive sufficient volume of sea water from the ocean and have become highly productive. The increased salinity of water in certain areas removed the natural barrier for the penetration of destructive conch, *Thais*, which moved inland and invaded productive oyster areas. These facts are mentioned to illustrate the highly complex situations which may arise in an oyster habitat as a result of human activity.

Pollution caused by the discharge of municipal and industrial waste materials is undoubtedly the major factor affecting the oyster bottoms. The effect of pollution is three-fold: (1) direct poisoning of shellfish; (2) smothering of shellfish grounds by sludge; and (3) rendering the water unsuitable for harvesting shellfish because of high bacterial content and danger of typhoid or paratyphoid infection.

According to the statement taken from the 1951 pamphlet of the U. S. Public Health Service, the pollution of American waters by municipalities and industries is equivalent to the untreated sewage of a population of more than 150,000,000 persons. The effect of industrial wastes is equivalent to more than half of this pollution. A very large proportion of municipal or industrial plants for treatment of waste are of inadequate capacity with the result that huge amounts of raw untreated sewage flow into our streams and bays. In the vicinities of large cities, such as New York, Boston, and Norfolk, Va. the sludge from domestic sewage almost completely smothered the formerly productive shellfish beds in these areas. The loss of these grounds is of no particular significance since all these bays are grossly polluted and shellfish taken from them is unfit for human consumption. The greatest loss to the oyster industry is caused at present by moderate and light pollution of water which can be demonstrated only by bacteriological analysis, and is sufficient to justify the closing of the grounds by public health authorities.

It is difficult to estimate the total acreage of oyster beds taken out of production because of the sanitary consideration. The closed grounds usually are not confined to the outlines of shellfish bottoms but cover larger areas under water defined by lines drawn between some prominent shore points. Furthermore, some of the shellfish bottoms within the closed area may have been already abandoned and left unexploited. Some idea of the magnitude of the loss may be gained from the fact that in 1951, 395 separate growing areas in coastal waters were closed by state authorities because of the contamination of water. Nearly two thirds of this number were found in the New England and North Atlantic States along the coast from the northern part of Maine as far south as Delaware.

Industrial pollution presents less danger to human health than domestic sewage, for it does not usually carry waterborne diseases such as typhoid, dysentery, enteritis and cholera. Some of the industrial pollutants are, however, highly toxic to fish and shellfish. While fishes have a chance of escaping death by swimming away from the affected area, shellfish can only temporarily protect themselves by withdrawing inside their shells and stopping feeding and breathing. At low temperatures, oysters may remain alive in this condition in water contaminated by toxic wastes for about a month or even longer, but eventually succumb and perish. Very often, however, the concentration of pollutant in sea water is so reduced by dilution that its toxic effect becomes apparent only after many weeks or even months of continuous exposure. Frequently the effect of a pollutant is an indirect one. Its presence in water upsets the chemical equilibrium of oyster environment to such a degree that growth of some of the microorganisms constituting the necessary food of shellfish is suppressed while the growth of useless and even harmful forms is encouraged. We find the instances of such effect in the waters receiving pollution from pulp mills using acid process: the so-called red liquor discharged from the mills contains considerable amounts of organic materials which greatly encourage the growth of a diatom, *Melosira,* with the results that oyster beds in polluted waters are covered with a thick layer of this alga smothering the live mollusk under its heavy carpet. Another example may be taken from the case of pollution of water of Great South Bay, Long Island, the former home of the Blue Point oyster. Rapid development of duck farms on the shores of the Bay resulted here in heavy contamination of water by washings containing duck manure. The resulting overfertilization of water caused tremendous development of green microscopic organisms which became so harmful to clams and oysters that the production of shellfish in the Bay has completely stopped.

Industrial pollution sometimes reaches gigantic proportion. Thus, according to the U. S. Public Health Service estimate (1952) the waste of nine sulphite mills dumped in the water in one area of the Pacific Coast was doing damage equal to the untreated sewage from eight million persons. The total population of the area in question was less than five million.

The effect of pollution may persist for a long time. For instance, the bottom of the Damariscotta River in Maine at the site of the famous oyster-shell heap is still covered with a layer of sawdust two or three feet deep, although the mills which dumped the sawdust in the river ceased to exist more than 50 years ago. Although temperature, salinity and other conditions of this part of the river are suitable for oyster growth, the physical impairment of the bottom made long ago makes it impossible to restore an oyster bed which for several centuries served as a source of food to Indian tribes who camped on the shores of this river.

Oysters have a remarkable ability to accumulate heavy metals in their bodies. Normally all oysters contain variable amounts of iron, copper, zinc, and manganese. In the waters receiving various industrial wastes from many plants along the shores of Connecticut and New York, the oysters frequently acquire dirty green coloration due to excess of copper and may accumulate in their bodies lead and other metals which make them unsuitable for human consumption.

The major factor in the decline of oyster production in the Chesapeake Bay States is inadequate management of natural oyster resources but not the pollution of water, although the latter constitutes a serious problem in the lower part of the Bay in the Hampton Roads area. The greatest portion of the Bay oyster bottoms, comprising about 250,000 acres, consists of public rocks from which oysters are harvested either by dredges or manually by tongs in accordance with the regulations promulgated by the respective State Governments. For more than a century the intensity of fishing over these bars exceeded the rate of natural replenishment by propagation and growth. Many of the bars were so decimated that their oyster population was reduced to less than 50 bushels per acre but dredge boats continued to remove these last remnants with the results that not only the oyster population was destroyed but even the material suitable for the attachment of oyster larvae was removed. There are many bars in the Bay which were depleted beyond recovery. Planting of shells by the state to counteract the ill effects of overfishing is both expensive and ineffective. Yet the public opinion in the Chesapeake States is strongly opposed to the idea of leasing some of the depleted grounds to private oyster growers. The situation is not unique for the

Bay States. It exists in a number of other states which adhere to the old idea of state management of oyster bottoms and oppose any large-scale development of oyster farming.

Substantial increase in the production of oysters in the Pacific States was entirely due to the introduction of a Japanese species, *Crassostrea gigas*, characterized by its rapid growth and large size. Both for biological and economical reasons, the industry depended on the import of seed oysters from Japan and virtually abandoned the idea of obtaining seed oyster locally.

From a brief examination of the recent trend in oyster industry we may arrive at the conclusion that factors contributing to the decline in production of oysters are man-made and therefore can be remedied.

In spite of greatly reduced acreage of productive oyster grounds, the industry has a good chance of surviving and even expanding provided more attention is paid to the oyster farming methods and to the quality of the shellfish offered to the customer. With the present retail price of about $1.00 a pint of shucked oysters and $1.50 a dozen of oysters on the half shell, the public is justified in demanding a product of highest quality, both with regard to the appearance and flavor. Oyster is a low calory food and as such cannot compete with meat, poultry, and fish. At the present price it became a luxury food, not an essential item of human diet. It is, of course, to the advantage of the oyster industry to emphasize the highly desirable dietary qualities of the oyster combined with their non-fattening nutritive value, but only the ability to produce oysters of really high quality will give the industry a chance to survive and progress. There is no doubt that further scientific studies can place oyster farming on a sound basis by making it possible to select the most desirable races of oysters; by learning how to grow and fatten the oyster more rapidly; how to obtain seed oysters in quantities annually needed for planting; and how to control the dangerous oyster pests. This goal can be attained by more effective development of individual oyster farming with the emphasis on the production of high quality shellfish commensurate with its present market price.

DISCUSSION

MODERATOR PRITCHARD: I did want to mention something in defense of the Chesapeake Bay Area. In the Virginia part of the Chesapeake Bay area where the history of the oyster production has favored to some extent the private planter who must for economic interests practice good conservation, production has maintained itself at somewhere near the high level of the turn of the century. I must admit that in the upper section, the Maryland section of the Bay, where the history of the production of the oyster has been unfavorable to the private planter, the production has decreased greatly.

I would also like to mention that Dr. Galtsoff has discussed several reasons for the decline of oysters in the United States and has mentioned the natural phenomena and pollution that might cause mortality. I might describe a recent mortality that occurred in the Chesapeake Bay area, the Rappahannock River, where a combination of factors led to the destruction of 90 per cent of the crop for probably a three-year period.

This event occurred in August of last year, following the two hurricanes that came across the Central Atlantic States and led to a great fall of rain. The flow of the Rappahannock increased in a short time to the highest level that had ever been recorded during August. The winds were such that this water did not actually appear as a flood along any stretch of the river and the oyster men did not consider there was an unusual freshet. Compared to springtime runoffs, this August runoff was not exceptional.

However, it came at a time when the oyster was less capable of keeping its mouth shut, and hence we had this marked freshet which decreased the salinity, and actually, although the oyster biologist was on the spot the day after mortalities were first observed, and only three days after it has been observed that the oysters were in good condition. Here they were dying although the salinity seemed favorable. Yet, there had been from our records of river runoff, a marked decrease in salt content over the beds. Probably even more markedly, this high runoff washed from the marshes a great load of organic matter which depressed the oxygen around the oyster beds to such an extent that we had a second factor involved.

There were also some industries upstream that contributed a heavy load of oxygen-demanding wastes. However, a calculation of their load of wastes compared to the actual drop in oxygen indicated that they could probably be contributing less than a tenth of one per cent of the total load that was added from the marshes. So, a variety of causes contributed to this high mortality at that time.

MR. GALTSOFF: I fully agree with his statement and I would like only to stress again that in the study of ecology of mollusks in general, oysters particularly, we deal very rarely with one factor that causes mortality. It is only an extreme case that doesn't call for study. It is usually an interaction of several factors which produce the final decline in growth and reproduction and then death. That is what makes the study fascinating because we have to deal with multiple factors just as we saw how the multiplicity of factors in the fresh water marshes are killing fish.

MR. GUNTER: Some several years ago I had occasion to work up statistics of production for all Gulf States and it was apparent that the production of every state on the Gulf had declined sharply over the past 40 years, say from 1900 to 1945, with the exception of Louisiana. Louisiana had maintained its production.

Now, I have thought about that a good bit since then and it seems to me there were two reasons. One is that Louisiana oyster-producing area was far removed from the centers of population and it was not so subject to industrial pollution and so on, and the other one is that Louisiana is the only state on the Gulf Coast where a man can go out and lease an oyster bed and handle it easily and cultivate it himself.

MR. GALTSOFF: You are quite right about that. I think that is correct.

RECENT DEVELOPMENTS IN THE CHEMISTRY AND HYDROGRAPHY OF ESTUARIES

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During the past fifteen years interest in the aquatic environment has greatly intensified. During World War II military needs in oceanography provided the impetus for expanded studies in fields that were to provide immediate benefits to fleet operations, as well as for fundamental studies that must form the basis of the practical applications. Studies of estuaries, a combination of the marine and fresh water environments, have enjoyed a similar, though not as spectacular, increase.

In some respects the sparsity of information concerning estuarine systems is anomalous. Estuaries are the front doors to the oceans and as such are a vital link in many non-military, as well as military marine operations. In addition, the high productivity and proximity to population centers gives the estuarine environment unique advantages when overall usefulness to man is considered. At first thought it may seem strange that in some respects our understanding of oceanic properties is better advanced than that of the smaller and closer parts of the aquatic world.

Interest in estuarine systems is shared among at least three groups. The users of estuaries—the fishermen, the mariners and developers of industry—form a large group that depend upon certain unique properties of these waterways for their livelihood. Conservationists, who frequently are also users of the system, would insure that man's utilization of these resources be on a continuing basis and at as high a level as possible, form a second rather large group. Thirdly, there are the scientists who are interested in estuaries primarily because they exist and their behavior is poorly understood. At times it appears that the interests of these groups are at crossed purposes. Despite this, all of these groups share a common desire—the desire to be able to predict what certain estuarine features will be at some future time. Prediction as used here has no mystical qualities usually associated with crystal balls. Actually prediction is a goal of all sciences and has reached a rather high state of development especially in astronomy, and in meteorology. Although we are not now at the stage where predictions of estuarine properties can be made with the accuracy and precision that can be done for eclipses of the sun or the moon, we have reached the stage where we can now indicate some of the features that will appear in a prediction system.

The discussion that follows is not an attempt to review and summarize all the published works dealing with the hydrography and chemistry of estuaries. Rather, it is an attempt to bring together for purposes of contrasting and comparing several groups of studies that, in the opinion of this author, have inherent features that contribute much to the basic problems of prediction of estuarine properties.

ESTUARINE HYDROGRAPHY

Studies in estuarine hydrography deal with the circulation within estuarine systems, with the mixing processes between fresh and sea water, and with the relations between these properties and those that are thought to control circulation and mixing.

Knowledge of circulation patterns and mixing processes provide the basis for the solution of many practical problems that become more and more pressing as the uses of estuaries increases. It is an unfortunate fact that two major users of these systems are incompatible when taken to extremes. Industrial developments frequently are located in estuarine regions because the immediate problems connected with industrial waste disposal are simplified. Frequently the availability of fresh water for industrial uses can be found at the same location as a connection with the ocean which provides the ultimate in dilution and assimilating capacity for industrial wastes. With an increase in population, brought into the region by the expanding industries, there is an expanding market for food, a part of which is supplied through an intensification of the fishing effort in the region. The end result of this autocatalytic process is well known. Even without this conflict of interest, results of hydrographic studies can be important information to both the fisheries and the industries that are developed along the shores. The conflict emphasizes the importance of such studies.

Substances that are either suspended or dissolved in estuarine waters will be distributed and dispersed by the currents of the region. Thus, the dispersal of eggs and larval forms of organisms that use estuaries as hatcheries are completely at the mercy of the circulation of the region. Similarly the practicability of taking uncontaminated process water from one location in an estuary while disposing of wastes in another can be decided only when the circulation and mixing of the region is understood.

A recent paper by Pritchard (1955) provides a convenient starting point in a discussion of estuarine hydrography. In this study a sequence of net circulation patterns is shown, in which progression through the sequence is associated with variations in the width and depth of the estuary, in river flow, and in tidal velocity.

As used here net circulation involves the kind of motion that would be observed if measurements of currents were made continuously over one or more tidal cycles and the upstream flow produced by the tide then subtracted from the downstream flow. This does not imply identity with a tideless system, only that direct consideration of tidal motion is eliminated. The four types in the sequence are shown in Figs. 1 through 4. Note that the progression from type A to type D

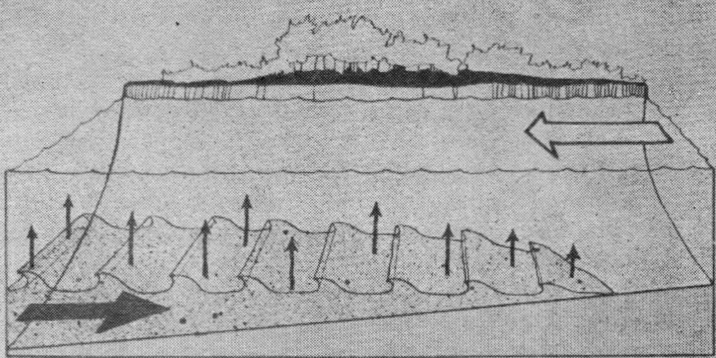

Figure 1

Type A Estuary

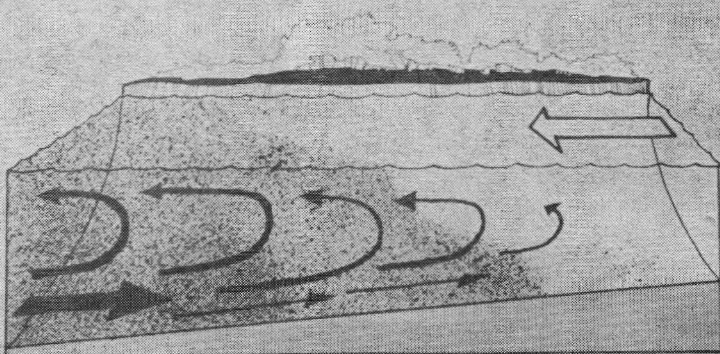

Figure 2

Type B Estuary

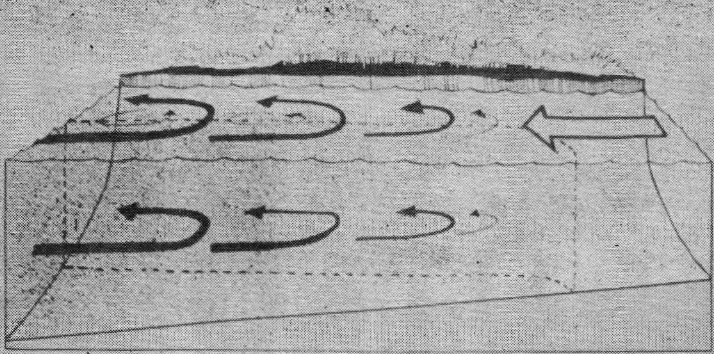

Figure 3

Type C Estuary

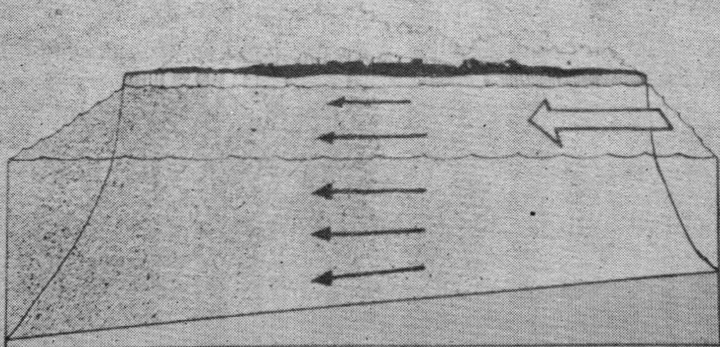

Figure 4

Type D Estuary

is in the order of decreasing vertical stratification. Type A is an example of extreme vertical stratification, a condition associated with high river flow compared to tidal flow. The top, fresher, less dense river water flows seaward and at the same time there is a relatively small upstream flow of sea water along the bottom sufficient to replace the salt that has been mixed into the top layer and carried seaward. Other things being equal, if the tidal flow now increases there will be a greater tendency for mixing to occur between the two layers. The increase of velocity over bottom roughnesess, for example, produces turbulence and mixing between the two layers. More salt will then be carried into the seaward moving upper layer, and in order to maintain a steady state the upstream flow of the lower layer must increase to replace the salt.

The tidal motion appears to be providing the energy necessary for mixing between the two layers. As a consequence of mixing of salt water from the bottom layer into the seaward moving top layer the net seaward flow of water may be many times greater than the river discharge. Redfield (1952), for example, noted that in the Strait of Juan de Fuca the energy supplied by the tide causes sufficient mixing in the channels of the San Juan Islands to produce a net seaward drift fifteen times that of the river discharge.

As tidal flow is further increased, or river flow decreases, the estuary will take on the characteristics of type C or D system. In relatively broad estuaries, ones in which relatively large distances are available for lateral mixing, type C circulation may be observed. In this case at any given location, there will be no vertical stratification but both lateral and longitudinal gradients will exist, thereby setting up a circulation pattern with upstream flow along one shore and downstream flow along the other. Type D estuary will occur when river flow is relatively low compared with tidal flow and the system is relatively narrow.

The relations between tidal flow, river flow, width and depth and the character of the net circulation were arrived at by Pritchard by a consideration of the relative importance of the several terms in the basic salt balance equation. Considering the system in three dimensions, (longitudinal, lateral and vertical axes) the salt balance equation indicates that changes in salinity can occur by advection along all three axis and by turbulent, diffusive processes in all three axes. The type D estuary points out graphically the distinction between these kinds of processes. In this case where there is both vertical and lateral homogeneity, the flow or advective motion will be everywhere downstream. Therefore, in order to maintain a steady state condition, that is to keep a constant longitudinal distribution, there must be longitudinal, non-advective or turbulent flow directed upstream that just balances the advective downstream flow.

These estuarine types provide a graphic demonstration of the importance of an understanding of the hydrography of a region in which practical problems connected with fisheries and with waste disposal are being considered.

It should be noted that in all cases mechanisms prevail whereby substances that may be introduced into one part of the estuary can move both up and down stream. Two other graphic demonstrations of dispersion upstream in estuaries have been noted. Bausfield (1952) observed that early stages of *Balanus improvisus* larvae were found in the surface layers of the downstream end of the Miramichi Estuary whereas the cyprid stage predominated in the lower layer of the upper end of the estuary. Similarly, Pritchard (1952) observed that the two layered system in the James River, Virginia, provided the mechanism for carrying larval oysters approximately twenty miles upstream from the brood stock to a region of heavy set. The length of larval life coincided with the transport time predicted from measured values of net upstream velocities in the lower layer.

With these models of etsuarine types in mind, it is possible to examine and evaluate a few other studies with a better appreciation of the complexities of the problems.

Ketchum (1951) developed an empirical theory of estuarine circulation that has since been applied to a variety of problems in many estuaries. Because of its empirical nature it also has been the subject of a certain amount of the theoretical probing in an effort to learn whether or not the technique could be applied to the entire spectrum of estuarine situations, and to find a theoretical rationalization of the empirical features of the model.

Ketchum's technique divides the estuary into segments of a length equal to a tidal excursion and assumes that there will be complete mixing within each segment at high tide. He then examines the exchange of river and sea water that must occur between segments in order to maintain steady state salinity distribution.

The techniques for carrying out the computations that result in a predicted salinity distribution, have considerable appeal as the primary information needed consists of river flow data, values of tidal range, and topographic charts, all of which can usually be obtained without conducting a survey of the region.

Ketchum's technique provides the means of calculating the average age of river water, in tidal cycles, in each segment. It therefore becomes possible to calculate the rate with which river water moves through the estuary, and by a combination of this rate with known biological or biochemical rates it becomes possible to assess the steady state distribution of various kinds of pollutants throughout an estuary. Ketchum (1951a) discussed the application of his technique in evaluating the dispersion of an essentially inert contaminant, using the Raritan River and Bay as an example. Later, Ketchum *et al.* (1952) attempted to combine the purely physical processes of circulation with rates of predation and bactericidal action of sea water, to obtain a prediction of *E. Coli* distribution in the Raritan River. They concluded that the bactericidal action of sea water was the most important process of those considered in the reduction of the bacterial population and that certain unevaluated processes had greater influence than either dilution or predation. Ketchum (1954) examined the combined effects of predicted circulation with the reproduction rates of a variety of planktonic organisms and obtained criteria by which a prediction of population increase, steady state population, and population decrease was made.

Several studies have been made which bear on the generality of Ketchum's treatment and afford a rationalization of some of the empirical features in terms of fundamental hydrodynamic theory. Ketchum's assumption that no vertical or lateral stratification exists within a segment of an estuary of length equal to a tidal excursion is not realistic in many estuaries. If, despite this, Ketchum's technique is generally applicable, it follows that the characteristics of the turbulent mixing processes are similar in all estuaries and that a mixing length can be characterized by a tidal excursion. Arons and Stommel (1951) sought a clarification of this situation in a theoretical treatment of estuarine circulation. They obtained an expression for the ratio of mean estuarine salinity to ocean salinity in terms of a dimensionless parameter, called the "flushing number," and a length ratio involving the total length of the estuary and the location of a given salinity ratio. A family of curves was obtained, for varying assumed values of the "flushing number." Ketchum's data for the Raritan River and the Alberni Inlet showed agreement to two of the curves, each with a characteristic "flushing number."

This was initially interpreted as indicating a similarity in the character of the mixing processes in these estuaries. There is, however, nothing in this treatment that permits a detailed comparison of two systems, one of which is vertically homogeneous, the other stratified.

In a later study Stommel (1953) reconsidered this problem. He pointed out that Ketchum's technique was not applicable to the Severn estuary, a system that fits all of the requirements of Ketchum's analysis. The characteristic mixing length was in this case about 1/1000 of a tidal excursion. Stommel then developed a theoretical model in which it was possible to examine changes in the eddy diffusivity, essentially a measure of the extent of turbulent mixing, at various locations in the estuary. Applied to the Severn, Stommel found the range of eddy diffusivity to be 80 to 1040 sq.ft./sec., with the maximum value at the location of the Severn bore, a region where one would expect turbulence to be large.

If Stommel's comment "that the method of the exchange ratio is not nearly so general as was proposed" is valid it would be extremely useful to know when the technique can be used and when it will give anomalous results. Unfortunately no clear-cut answer can be given. It seems obvious, however, that a simple test can be made to determine its applicability to many practical problems. If the predicted salinity distribution in an estuary shows good agreement with the prototype it can be assumed that the steady state distribution of a contaminant can be predicted by the technique.

Several studies reported by Pritchard and his co-workers are examples of what can be called a semi-theoretical approach to estuarine circulation. Briefly, these studies have developed by, first, the construction of a theoretical model based upon fundamental hydrodynamic principles, giving a mathematical expression for an over-all process in terms of all conceivable mechanisms by which that process can occur. Then, by designing suitable experiments in which measurements are made in an actual estuary, the relative importance of each of the processes are evaluated. For example, Pritchard (1952-1954) developed an expanded form of the fundamental salt balance equation, in which the instantaneous local rate of change of salinity is equated to a sum of terms that describe the changes produced by advective processes along all three axes, by random or diffusion processes along all three axes, and terms that take into account changes associated with changing geometry. From an extended series of observations of velocity and salinity changes in the James River, Pritchard (1954) concluded that the two processes, (a) mean horizontal advection and (b) nonadvective vertical flux were the primary processes responsible in establishing the steady state distribution. In addition, he noted that the vertical nonadvective flux showed a direct increase with increasing tidal velocities.

Kent (1955) considered turbulent diffusion in a well mixed estuary. He developed a mathematical model which describes the behavior of a transient state pollutant in such a system. The theoretical model was then compared with the results obtained from experiments in the Corps of Engineers model of the Delaware estuary, in which dye was released and its distribution in time and space followed over 24 to 30 tidal cycles. The significant results of this study are, that in general the observed distributions are predictable with good agreement from the theory; that features which appeared as anomalies in the model tests are rationalized by the theory; and that the coefficient of eddy diffusion rather than being a constant throughout the system is related to tidal velocities, river flow and position within the estuary. Finally, Kent's findings appear to substantiate Stommel's (1953) comment "... it does not appear likely than any good purpose can be served at present by making *a priori* suppositions about turbulent mixing processes."

Basically, studies in estuarine hydrography appear to be developing along two general lines. The semi-empirical approach illustrated by Ketchum's studies, and the semi-theoretical approach similar to the works of Pritchard and Stommel. At present both approaches appear essential to a vigorous development of the science—each tending to point out profitable avenues of attack to the other and acting as mutual testing grounds for individual studies.

CHEMICAL STUDIES

Chemistry is more or less of a hand maiden to all types of estuarine studies. Investigations that have their primary objectives in hydrography, marine biology, fisheries research, and industrial and domestic waste disposal all receive much primary information through the use of chemical principles and techniques.

In all phases of estuarine studies sampling the system presents problems that are not found in limnological and marine studies. The relatively rapid changes produced at any selected geographic location by the periodic oscillation of the tides makes it necessary to keep a careful check on sampling time, stage of the tide, and location. Longitudinal salinity gradients and tidal excursions may be such that at extremes of the tide, salinity differences of up to 5°/°° can be observed at a fixed location.

Sampling bottles of the type commonly used in oceanographic and limnological studies are in general not ideally suited to estuarine studies. The familiar Nansen type reversing bottle with restrictions at both ends has poor flushing characteristics. It therefore is not suited to sampling a system in which strong vertical gradients exist and in which longitudinal tidal displacements can be large. The Kemmerer type sampling bottles has considerably improved flushing characteristics and has been extensively used in estuarine field studies.

The Van Dorn Sampler (Van Dorn, 1955) combines many characteristics desirable in a "grab sampler". It consists of a plastic cylinder which until the time of closure is unrestricted, thus achieving maximum flushing during descent. The sample is entrapped by the simultaneous insertion of "plumber helpers" into the ends of the cylinder. Motive power for the closures is supplied by a length of prestressed surgical tubing. The device is simple, inexpensive, and gives a sample uncontaminated by the metals usually employed in bottle construction.

The taking of bottle samples in estuarine studies has many inherent limitations. The question asked of any sample is, "What is the relation between the properties of the sample and those of the environment from which it was taken?" The most useful situation is when the properties of the sample give a measure of the mean properties of the universe. For example, sampling to obtain the salinity distributions noted in the hydrographic studies above must be such that the time mean salinity results from a measurement of a series of samples. In order to obtain the time mean, that is to eliminate the fluctuation produced by tidal oscillations, many samples must be taken over all stages of the tide. Such a procedure, although cumbersome—it requires that many measurements be made in order to get the desired parameter—is adequate when sampling for salinity which can be assumed to be continuous in time and space. Inherent in the procedure is the assumption that the form of the distribution of values about the mean is known or can be determined. When sampling for a determination of properties, which in contrast to salinity, may be discontinuous in space or time, and be of some unknown distribution in the intervals that they do occur, the disadvantages of "grab sampling" is obvious. The limitations are of special significance when sampling is for plankton and for dissolved chemical constituents that are not conservative properties.

In order to overcome some of these limitations at least two techniques have been proposed. In both cases a single sample is obtained which has the mean of the properties in the part of the environment sampled. The first of these was described in a report of the Special Development Division of the Scripps Institution of Oceanography (1953). It consists of a plastic tube containing a piston. In use the device is towed through the water and the piston slowly displaced by a propeller driven pump. The rate of intake of sample is at all times proportional to the speed it is being towed through the water. In practice the towing cable must be fitted with a depressor, if sampling at depth is to be obtained. With this arrangement several sampling devices can be towed simultaneously to give a measure of vertical distributions. Another type of integrating sampler was described by Carritt (1955). It consists of a pump and pipe line system, constructed entirely of plastic or glass in the sections that come in contact with the samples. It was designed to deliver samples of plankton and of water, uncontaminated by metals. In operation, the survey vessel steams at a constant known speed over the water while the pump takes water at a constant known rate. Ship's speed and the pumping rate are adjusted so that the inlet end of the hose takes all of the water in a cylinder of dimensions equal to the diameter of the hose and of length equal to the distance covered by the ship. Plankton is removed from the entire sample of water by a net. From 500 to 1000 liters are usually taken while steaming 5 to 10 miles. A water sample (1 to 2 liters) is obtained by taking a constant fraction of that passing through the pipe line. Thus, plankton and water samples are obtained that provide a measure of the mean of the properties at one depth over the region traveled by the ship. No attempt has been made to sample several depths by towing a depressor weighted cable carrying several hoses.

In estuarine studies it is a general practice, because of the sharp gradients observed, to make slight modifications in the Knudsen chlorinity titration, to achieve great ease of operation and speed of titration. The slight reduction in accuracy usually is of no consequence. It is usually necessary to use ordinary straight type burettes having a continuous scale rather than the bulbated type, used in the Knudsen method, which is calibrated only over a limited volume range.

Problems associated with the use of "sub-standard" sea water, as a means of calibrating the titration procedure have been discussed by McGary (1954). He recalled the fact that standardization of the Knudsen titration procedure is possible, if Knudsen's Tables of Corrections are to be used, only when "Eau de mer Normale" having a chlorinity of 19.38°/°°, or when natural sea water (unadjusted by the addition of sodium chloride) having a chlorinity of very nearly 19.38°/°° are used as primary and secondary reference solutions. This makes the titration of samples of low chlorinity, as are found in parts of all estuaries, cumbersome. Using the same basic stoichiometric relations used in the construction of Knudsen's tables, McGary derived a relation, that can be used in either tabular or graphical form, which permits the use of sea water of any chlorinity as a secondary reference solution.

Because of the sharp gradients found in many estuaries, the use of instruments that will give a continuous record or indication of salinity, is desirable. The Woods Hole Oceanographic Institution Salinity-Temperature-Depth recorder (STD) and the Chesapeake Bay Institute Conductivity-Temperature Indicator (CTI) are examples of attempts to instrument this kind of measurement. These two instruments are examples of a class that use the classical kind of conductance measurement, together with a resistance thermometer, as the means of obtaining a measure of salt concentration. In all of these devices two or more metallic electrodes, usually platinum or platinized platinum, are in contact with the water. As a result of electrochemical processes taking place at the surface of the electrodes (polarization phenomena) and biological fouling with continued use over long periods, frequent recalibraiton of this kind of instrument is necessary.

The first attempt to circumvent this trouble appeared in the application of high frequency techniques to an "electrodeless" conductivity cell. In this application the electrodes which form a part of the conducting system are not in contact with the water. Thus, polarization and fouling are eliminated. Harwell and Hood (1954) described a recent model of this device. A precision in salinity of $\pm$ 0.04°/°° is claimed. The limiting factor here apparently is in the stability of the high frequency electronic circuits of the instrument.

More recently Esterson and Pritcherd (1955) described a device utilizing the transformer principle in the underwater sensing element. The unit is essentially a three element transformer in which a sea water path forms the secondary winding. A constant potential (60 cycle) is applied to the primary toroid winding. This induces a current, the magnitude of which is proportional to salinity, in the single turn "sea water winding." This in turn induces a current in the tertiary transformed element. The signal obtained from the tertiary element, which is proportional to salinity, is amplified and made to drive a calibrated counter. The underwater unit is completely encased in a plastic casting. There are no electrodes to be fouled. The electrical system involves only 60 cycle signals so that troubles with cable capacitance are minimized. Recent calibration checks indicate the instrument to be unusually stable. Repeated runs over a period of more than a month show departures of indicated chlorinity from titration values, in the range 0.50 to 18.00°/°°, to be not more than $\pm$ 0.01°/°°. This was also the design limit set by the linearity of the balancing component in the bridge circuit. The standard deviation of all of the chlorinity titrations performed by a manual potentiometric method was 0.0024°/°°. The inherent stability of this instrument together with its ruggedness and relatively simple electronic components suggests that it may be a useful tool in estuarine studies.

The need for very nearly continuous observations over extended periods at several locations within an estuary frequently strains the resources of an organization undertaking field operations. The cost of operating vessels and maintaining field parties is high. In an attempt to obtain broader coverage at reasonable cost, at least two attempts have been made to construct buoy type devices that contain recording equipment. One of these, an ultrasonic current meter was described by Middleton (1955). The instrument operates on the principle that there will be phast shift between an outgoing sinusoidal signal and that signal when received at a distance from the sending device. The magnitude of the phase shift is a function, among other things, of distance between and of the velocity of the water passing, the sender and receiver. With fixed sender and receiver, that alternate in function to eliminate temperature, pressure, and salinity effects, the system can be made to indicate water velocity. One of the principal advantages of the method is that there is no inherent static friction effect as found in propeller type instruments. The first model constructed was made to record with 8 mm movie camera operating at single frame exposures, currents in the range 0.08 to 5.1 feet/sec. and a repeater compass giving simultaneous indication of current direction. When used as a buoy device the batteries and power supply are built into the anchor unit.

A second recording buoy has been constructed to provide a semicontinuous record of conductivity and temperature at five depths beneath the buoy. The sensing elements are similar to those used in the Chesapeake Bay Institute, Conductivity-Temperature Indicator.

There is a growing literature, primarily from physiology, and biochemistry, concerned with the nutritional requirements of plankton organisms. Much interest is centered around requirements for substances, both organic and inorganic, that generally are referred to as "trace substances." The chemistry connected with these studies usually is highly specialized and in detail of interest primarily to the workers in the fields concerned. Of special significance to the present discussion are some of the motivations behind the studies and the implications of their results to the development of aquatic ecology.

There are a number of developments that have progressed along more or less parallel lines for many years that have a bearing on present day trends in the biological and ecological studies in all aquatic fields, and as will be evident, on many of the practical problems discussed in the symposium. In the highly abbreviated discussion that follows no attempt has been made to set out the material in chronological order nor to identify a finding with any particular branch of science from which it is taken.

In natural aquatic environments it has often been noted that a certain succession of species will be noted if the standing crops are examined at frequent intervals. Starting with the "spring flowering" it is found that the successive of species that make up the major portion of the standing crop throughout the year will be nearly the same from year to year. Reasons for this periodic appearance and disappearance of a given member of a population have long been sought. In many cases certain of the gross environmental properties appear to be associated with the rise or fall. Species that appear, for example, only for short intervals in the spring are reasonably associated with the temperatures, salinities and light intensities that characterize a given location at that time of year.

Riley (1939, 1946) in a classical series of papers, for example, showed that the seasonal fluctuations in a phytoplankton population could be accounted for, or was associated with, simultaneous changes in temperature, inorganic phosphate and nitrate concentration, depth of the water and size of zooplankton populations. The association or correlations that result from studies such as these appear as an excellent basis for prediction systems—ones that will permit us to say that a given species will appear at a stated time or that a population will reach a certain level. They appear as an excellent basis especially if one has mistakenly connected high correlation in the statistical sense with cause and effect.

Consider, however, a few other experimental findings. With only few exceptions, it has been found impossible to maintain a growing culture, especially marine phytoplankton organisms in *completely synthetic media*. This implies that it has been impossible to duplicate the environment in which these organisms are found. One of two conclusions seems certain here;—one or more requirements have not been met, or tolerance levels with respect to inhibiting influences have been exceeded.

In those cases where successful growth has been maintained the culture media invariably contains a large number of constituents, frequently low concentrations of organic substances such as vitamins, aminoacids, and lipids, as well as trace levels of many of the less common metals, such as cobalt, molybdenum, copper, zinc, vanadium, etc.

The essentiality of many of these organic compounds demonstrated *in vitro* experiments has special significance when one attempts to rationalize the succession of forms found in nature and when prediction systems are considered. Many of the substances are produced as metabolic wastes by limited classes of organisms. It seems reasonable to assume then that in order for an organism having a requirement for say one of the vitamins to grow, it is necessary for the organisms that produce the vitamin to either be growing or to have been in the environment in the immediate past. Disappearance of the producer organisms precludes the ultimate disappearance of the organism having the requirement.

Metalic constituents appear in a somewhat different role. They are not produced and destroyed in the same sense as are the organics. The roles that some of them play in the metabolism of organism have been discovered at least so far as certain terrestrial plants and animals are concerned. It has been shown, for example, that molybdenum is a component of an enzyme system that functions during the reduction of nitrate nitrogen, the form in which it predominates in the aquatic environment, to amino nitrogen, the form in which it must exist in order to appear in proteins. Similarly, copper and zinc are essential in other enzyme systems that catalyze other vital oxidation reduction processes.

There is at least one example, still hypothetical so far as actual significance in a natural system is concerned, that involves both an organic and an inorganic substance. It is known that certain dinoflaggelates have a specific requirement for vitamin B_{12}—so far as is known no other substance can substitute for the B_{12}. Vitamin B_{12} is produced by certain other groups of organisms. As noted above the existence of the producer organisms is essential to the development of the dinoflaggelates. Furthermore, cobalt is a constituent of vitamin B_{12}. The B_{12} producers must then have their cobalt requirement met before the chain that terminates in dinoflaggelates can be started. Although speculative at this time, chains of events of this kind involving only *limited parts* of a population which undergo *specific, characteristic reactions* with components in their environment may provide clues to the succession of species found in natural aquatic systems and offer the keys to means of predicting what can occur at some future time.

Lucas (1947) gave an excellent discussion of the kinds of interactions to be expected between organisms and metabolic products (he termed them "external metabolities") of other organisms. More recently Collier *et al.* (1953), Provasoli and Pintner (1954) and Johnston (1955) have clarified many of the relations suggested by Lucas.

The role of chemistry is clear in certain respects with regard to contributions that can be made to these phases of ecological studies. Many of the analytical problems are now obvious and the tools and methods for their solution in existence. In addition to finding what and how much exists in natural systems there is a growing need for the production of groups of "super-pure" chemicals that can be used in the concoction of media in which organisms can be grown and their requirements worked out.

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DISCUSSION

MODERATOR PRITCHARD: Of course, this is the area that I am most capable of commenting on. However, in the interests of time, I will restrict myself to one brief example of how man-made changes in one or more of the important factors which control environment can lead to drastic changes in the economic situation within an estuary.

This happens to be an engineering example rather than a biological one, but in the harbor of Charleston is the lower estuary of the Cooper River. Some years ago a hydroelectric development was completed on the upper Cooper, in which water from the Santee watershed was diverted into the Cooper. Prior to this diversion the flow of the Cooper was relatively low and the tidal range was sufficiently high so we had essentially a vertically homogenous estuary and the net flow was out in all depths. There was just a slow movement of water sufficient to get rid of the fresh water and carry it out to sea.

This slow movement carried out whatever silt there was, out of the river and there was no siltation problem.

Following the development of the Santee-Cooper project, when a great deal more fresh water was diverted to the Cooper, the increase in river flow-over, compared to the tidal flow led to some stratification in the estuary and to the development of a circulation which had an inflow along the bottom. This led to the fact that instead of, as had been thought by many of the engineers, that the increased flow would help wash out the sediments, this increased flow led to the fact that the sediments which were brought down by the river, settled down and were maintained in the estuary by the upstream flow. Also, sand from the outside estuary region, were brought in by the flow along the bottom. The annual dredging costs went up from the order of $10,000 to the order of a million dollars a year.

This has greatly changed the economic relationship between the cost of maintaining the harbor and the gain in electric power from the project.

RECENT CLIMATIC FLUCTUATIONS IN MARITIME PROVINCES[1]

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The recent widely-discussed climatic fluctuation has been given increased attention by climatologists during the past twenty years. This is undoubtedly due in part to questions concerning its nature, extent, and especially its causes, which have been raised by botanists, zoologists, students of conservation, and others as the fluctuation has made itself felt in their respective fields of endeavor. An almost overwhelming amount of diverse evidence of marked changes in temperature and precipitation conditions in certain regions has been showered upon the climatologist, always with the question: why?

INTRODUCTION

Ahlmann (1948a; 1953), Manley (1953a; 1954) and others have recently reviewed these climatological fluctuations and have summar-

[1] In the absence of the authors, this paper was read by Dr. D. W. Pritchard.

ized evidence from geophysics and geobiology. In this paper, we shall describe the climatic fluctuations as revealed by many maritime stations in the higher middle and Arctic latitudes of the North Atlantic area, and we shall draw attention to difficulties of interpretation inherent in climatological records. Consideration will also be given to the physical reasoning and various meteorological models that can be used to account for these anomalies.

Time orders. A convenient, although artificial, way to bring order to the chaos of the fluctuating time-dependent variables of the climatic-change spectrum is to devise arbitrary "time orders," corresponding to supposed fluctuation intervals present in the time series. Table 1 sets forth six time orders of climatic change, along with their respective durations and examples from climatic history. They represent selected intervals from an entire spectrum which should be considered operating at any particular place and at any particular time.

TABLE 1. SCHEMATIC DIVISION[1] OF THE CLIMATIC-CHANGE SPECTRUM [MODIFIED AFTER MANLEY (1953a)]

Time order	Approximate duration	Example
I. Recent	Few years to 1 generation	Dust-bowl period
II. Historical	1 to 5 centuries	"Little ice age" (approx. 1600 to 1800)
III. Post-glacial	500 to several thousand years	Climatic optimum (approx. 6000 to 3000 B.C.)
IV. Glacial	10^4 years	Wisconsin glaciation
V. Minor geological	10^6 years	Ice age
VI. Major geological	10^8 years	Paleozoic era

[1] Time orders I and II may conveniently be termed "climatic fluctuations," the remaining time orders "climatic variations."

Our discussion is primarily concerned with a case belonging to time order I, the recent fluctuations. However, fluctuations of time order II are, of course, woven into climatological data and in some cases are reflected to a greater degree by various climatic indicators than are fluctuations of shorter duration.

Data smoothing. Climatologists frequently prefer data smoothed by overlapping ("running") means, to reduce the great variability ("noisiness") inherent in normal climatological series. The smoothed set of data reveals fluctuations (where present) of a time order greater than that of the chosen smoothing interval. These fluctuations are usually completely obscured by the large year-to-year differences in unsmoothed data.

Cycles. The term "fluctuation" is to be clearly distinguished from the term "cycle." The latter refers to the recurrence of weather in the same order at rather regular intervals. Reasonably stringent application of the definition leads to the conclusion that there are only two definitely established cycles in weather behavior: the diurnal cycle and the annual cycle.

It can be shown that *any* climatological series can be decomposed into innumerable cyclic components, each with its own period and amplitude (Brunt, 1925; 1937). A series thus specified can be extrapolated mathematically into the future. However, unless *all* cyclic (harmonic) components have been determined, or unless the established components have a physical basis applicable to the atmosphere, any extrapolation is useless as a predictive device.

The atmosphere is so complex a system that it is unlikely either that climatological series can be fully determined or that all the physical factors and their effects can be completely discovered. If such a situation could be attained, the climatologist would utilize the newly discovered physical laws directly and not resort to harmonic analysis. The fallacy of this cycle approach to climatic changes should be apparent; yet the literature abounds with studies of a cycles-for-cycles-sake nature.

Probably the two most famous cycles are the 11-year sunspot cycle and Brückner's cycle of 35 years. Although apparently they can be verified at particular locations and for short periods of time, their inability to predict reliably future climatic events betrays the "accidental" nature of their existence. Several references to discussions of (supposed) climatic cycles may be of interest to the reader: C. E. P. Brooks (1954), Conrad (1953), Dewey (1952), Dewey and Dakin (1949), Johnson (1946; 1950), Kimble (1955), and Tannehill (1955).

Record complexities. Mitchell (1953) has presented a schematic outline of factors that may cause a temperature record to show significant long-period change. Since these considerations are basic to a discussion of this nature, the diagram is reproduced as Figure 1. It amply illustrates the complex of factors that must be taken into account when considering indicated observed temperature fluctuations. Some changes may be apparent only because of the observational procedures. Some may be real but due primarily to the effect of a growing city, a complication of serious character because our longer temperature records come largely from cities during the era of industrial expansion.

CLIMATOLOGICAL DATA

Standardized records of climatological elements have usually been kept only since the establishment of government weather services in the latter part of the 19th century. Clayton's (1927; 1934; 1947)

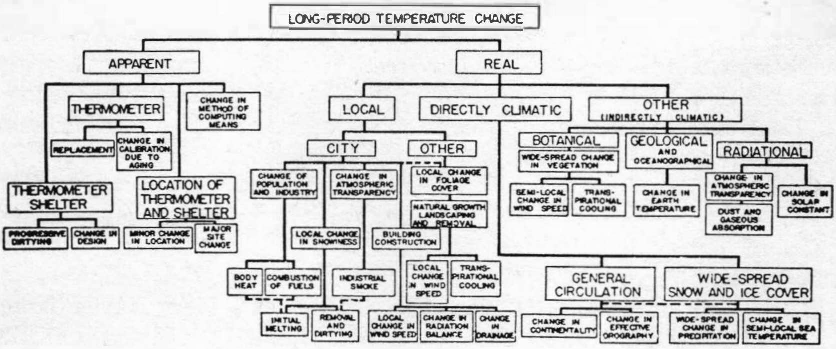

Figure 1. Block diagram of factors causing significant secular changes in meteorological surface-temperature records [after Mitchell (1953)].

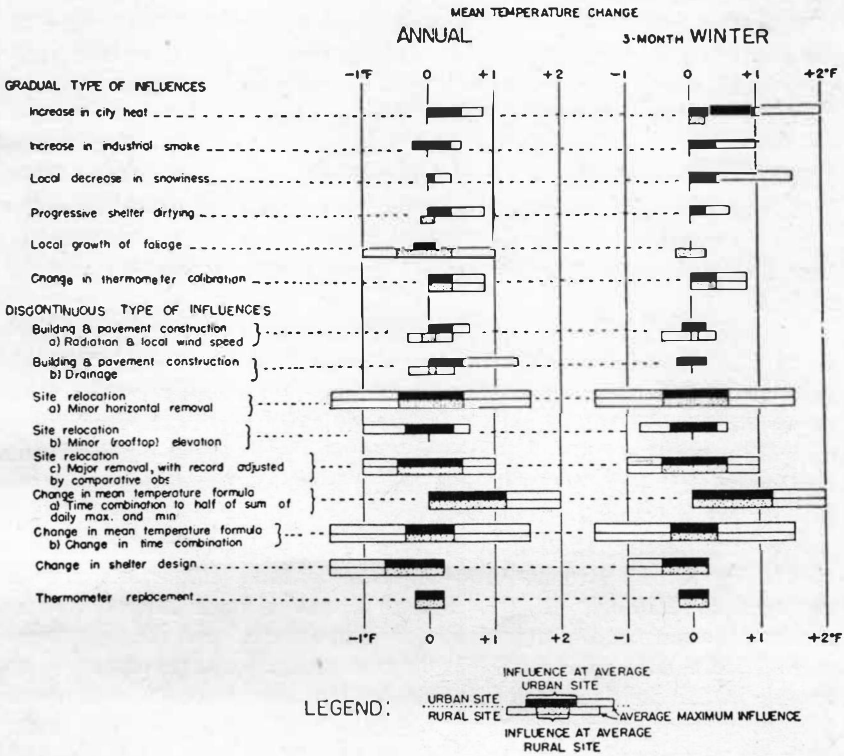

Figure 2. Estimated world-wide average and average extreme magnitudes of instrumental and local-environmental influences on secular records of annual and winter mean temperatures over 100-year period, based on observational and environmental changes typical of past century [after Mitchell (1953)].

several collections of records of monthly mean temperatures and pressures, and monthly precipitation totals, from throughout the world constitute a fundamental data source. The latest supplement, with records from 1941 to 1950, is now in the process of being published.

Continuous temperature records spanning more than a century and a half are rare; exceptional is the Stockholm record (Hamberg, 1906), which observes its 200th anniversary this year. However, lengthy records have been developed for a few stations by judicious combination of data from various individually-kept observations. Notable among such records are those for Trondheim from 1761 (Birkeland, 1949), Utrecht from 1706 (Labrijn, 1945), and New Haven from 1778 (Loomis and Newton, 1866; Clayton, 1927). It is hoped that the interest in early extant records recently shown by the U. S. Government and others (Ludlum, 1955; Havens, 1956) will result in further attempts in this direction.

This "bridging" of several records to form one continuous series for a particular station has been extended to include a synthesis of individual records from a climatically homogeneous region. Manley (1953b) has been successful in developing a series of monthly mean temperatures for central England dating from 1698, while Baur (1953) presents similarly derived monthly mean temperatures from 1761, and monthly precipitation totals from 1851, for central Europe.

Since the majority of recent climatic analyses deals with temperature fluctuations, these changes will form the main content of this review.

Homogeneity. The most serious problem encountered in any analysis of a climatological series is that of record homogeneity. That is, have any extraneous factors been introduced which will result in an apparent climatic trend when no actual change exists? Statistical approaches to this problem, developed by Conrad (1949) and outlined by Conrad and Pollak (1950) offer some hope in detecting non-homogeneity and minimizing its effects.

Factors affecting the homogeneity of records have been briefly reviewed by C. F. Brooks (1954), who mentions important results reported by Mitchell (1953). Figure 2, taken from Mitchell, summarizes the nature and magnitude of instrumental and local-environmental influences on records of temperature, a problem discussed at length in Mitchell's article. It is seen that the magnitude of some factors is great enough to account completely for an apparent trend in mean temperature on the order of 1 or 2°F. in a record of 100 years. In this connection, it is interesting to note that the city of New Haven, by virtue of its wintertime artificial heat, causes winter mean temperatures to register 1°F. higher in the city than at the rural municipal airport. Although the majority of recent studies has been concerned with the homogeneity of temperature records, analogous situations exist with respect to other climatic elements.

With these difficulties in mind, we can turn to a review of climatological evidence for changes during recent years. The problem of homogeneity is present, to a greater or lesser extent, in each of the records mentioned below. Lacking quantitative evaluation, however, we will necessarily have to asume that the evidence is both "real" and "directly climatic" in the terminology of Figure 1.

FLUCTUATIONS IN CLIMATIC SERIES

Climatic changes of time order I, the "recent" fluctuations, are quite clearly indicated by 10-year overlapping mean temperatures. It is convenient to designate a 10-year mean by prefixing the letter d (from *decem*) to the last year in the interval covered by the mean. Thus, December d1900 means: the December mean temperature for the 10-year period ending with 1900. Similarly, the letter t (from *triginta*) is used with a particular year to designate a 30-year period (Lysgaard, 1949).

The magnitudes of year-to-year changes will be decreased by the smoothing process. From a statistical standpoint, the following generalizations can be made concerning the significance of (say) a 2°F. change in mean monthly temperature during a particular interval of time: such a temperature change would be more likely to occur by chance in winter than in summer, in high latitudes than in low latitudes, and at stations which are climatically more continental than oceanic, because of the inherently greater variability of temperature under the former set of circumstances. The question of practical significance, as opposed to statistical significance, must be related to the geophysical and geobiological phenomena presumably influenced by climatic fluctuations (*e.g.*, glaciers, growing seasons, tree lines).

Rubenstein (1946) had mapped departures of December mean temperatures for d1938 from the 58-year December averages ending with 1938, over most of the northern hemisphere. Positive anomalies in excess of 2°F. appear from the eastern Canadian Arctic Archipelago eastward to extreme western Arctic U.S.S.R. An elliptical center of maximum positive anomaly (over 7°F.) encircles most of northern Greenland and Svalbard.

This large positive area is flanked by two cells representing negative departures of d1938 from the longer-term averages. To the west, values in excess of —2°F. are found in extreme northwestern Canada and eastern Alaska, reaching —3°F. in the Yukon region. The eastern cell, with departures in excess of —3°F., appears to be centered east of the Caspian area. The —1.8°F. (—1°C.) isanomaly line passes roughly north-south through the Caspian Sea. The lack of a positive cell in the Bering Sea area (approximately 180° longitude from Svalbard) and the southward displacement of the Asian cell of negative anomalies indicate marked asymmetry in the spatial distribution of these "recent" anomalies.

Tables 2 and 3 have been derived from several sources: Norway (Birkeland, 1936; Hesselberg and Birkeland, 1940), Sweden (Ahlmann, 1953), England (Manley, 1953a; 1953b), and the United States (Kincer, 1946; Spar, 1954). They show the magnitude of mean-temperature fluctuations at various maritime stations since approximately 1890. The data have been interpolated from curves in several cases and should be regarded only as rough approximations.

TABLE 2. MAGNITUDES OF THE RECENT CLIMATIC FLUCTUATION SINCE D1900 IN WINTER. DECADAL MEANS OF JANUARY MEAN TEMPERATURE (°F.) AT STOCKHOLM, CENTRAL ENGLAND, AND NEW YORK; DECADAL MEANS OF WINTER (DECEMBER, JANUARY AND FEBRUARY) MEAN TEMPERATURE AT OTHER STATIONS. ASTERISK INDICATES CURVE RISING AT DATA BOUNDARY.

Station	Value and time of minimum	Value and time of maximum	Temperature difference
Stockholm	25.3; d1922	30.9; d1939	+5.6
	23.7; d1947		—7.2
Central England	38.8; d1912	40.8; d1928	+2.0
	36.6; d1948		—4.2
New York City	29.6; d1905	33.1; d1915	+3.5
	29.8; d1927		—3.3
		35.0; d1937	+5.2
	30.6; d1948		—4.4
W. Spitsbergen	—2.4; d1918	11.1; d1938*	+13.5
Tromso	24.6; d1921	28.4; d1938*	+3.8
Bergen	34.5; d1924	36.9; d1938*	+2.4
Oslo	25.7; d1924	28.9; d1938*	+3.2
Entire U. S.	32.5; d1918	34.7; d1935	+2.2

TABLE 3. MAGNITUDES OF THE RECENT CLIMATIC FLUCTUATION SINCE D1900 IN SUMMER. DECADAL MEANS OF JULY MEAN TEMPERATURE (°F.) AT STOCKHOLM AND CENTRAL ENGLAND; DECADAL MEANS OF SUMMER (JUNE, JULY AND AUGUST) MEAN TEMPERATURE AT OTHER STATIONS. ASTERISK INDICATES CURVE RISING AT DATA BOUNDARY.

Station	Value and time of minimum	Value and time of maximum	Temperature difference
Stockholm	60.6; d1911	65.5; d1945	+4.9
Central England	59.6; d1922	61.7; d1952*	+2.9
W. Spitsbergen	38.3; d1918	40.3; d1927	+2.0
Tromso	48.2; d1911	52.2; d1938*	+4.0
Bergen	54.9; d1924	57.4; d1938*	+2.5
Oslo	59.5; d1930	61.7; d1938*	+2.2
Entire U. S.	71.3; d1912	73.3; d1938	+2.0

The outstanding features of these two tables can be summarized as follows:

1. Generally speaking, the first half of the present century has been characterized by warming in the area bordering the North Atlantic, in both winter and summer. While the greatest warming seems to have taken place in higher latitudes, there is no overwhelming regularity in the pattern of change. Nor is the change identical in winter and summer.

2. In northwestern Europe, winter mean temperatures began rising earliest in northernmost latitudes (West Spitsbergen, d1918), reaching a maximum over the entire area about d1938 or d1939. The severe Januaries of 1940, 1941 and 1942 are reflected in the minima for Stockholm (d1947) and central England (d1948), after which the temperature again rises. The Norwegian stations would no doubt show similar behavior if analyses beyond d1938 were available.

3. Winter temperatures in the United States as a whole began to rise simultaneously with those in West Spitsbergen; however, they culminated in a maximum about 5 years earlier (d1935). The New York City series gives three minima and two maxima since d1900, with the d1937 maximum and the d1948 minimum occurring approximately simultaneously with similar European fluctuations.

4. Summer means have been rising at most stations since the 1910's or 1920's. Although a maximum was reached in West Spitsbergen in d1927, Stockholm temperatures did not start to fall until after d1945, while at other northwest European stations (*e.g.*, central England) the rise was still continuing in d1952. Kincer's (1946) curve for the United States shows a definite maximum about d1938.

Historical fluctuations. These patterns of short-period fluctuations should be considered superimposed upon the entire climatic-change spectrum. A simplification can be made, however, by taking into account only time order II, the "historical" fluctuations of climate. When climatic series are smoothed by 30-year overlapping means, the fluctuations of this time order can be brought out.

Lysgaard (1949) and Willett (1950) have attempted to map changes in climatic elements over the entire world. In considering spatial distribution of fluctuations of temperatures, Lysgaard's map delineating the difference between January mean temperatures of t1940 and t1910 can be used. The map is similar to Rubenstein's in one respect: large positive differences are found over Greenland and northern U.S.S.R. However, the 1.8°F. (1°C.) isoline of difference includes considerably more area on Lysgaard's map. It encompasses most of Canada and the eastern United States, before arching far to the north and entering Europe in North Norway. It swings sharply southward through Europe and travels eastward across the Black Sea and the southern part of the Caspian Sea. The 1.8°F. isoline then runs generally northeast from the Caspian Sea, leaving the continent by way of Kamchatka.

Positive temperature differences in excess of 3°F. are limited to Arctic U.S.S.R. and most of Greenland, while maximum values (over 5°F.) are centered on the Greenland west coast. As in the case of the 10-year means, "die Erwärmung der Arktis" is again emphasized (C. E. P. Brooks, 1938; von Hennig, 1949; Scherhag, 1937).

A similar map for July is less definite, positive differences in excess of 2°F. being limited to the interior of North America and northern Scandinavia.

Data from about 1820 are available for several stations, as shown in tables 4 and 5 (Lysgaard, 1949). The data may be briefly summarized as follows:

TABLE 4. MAGNITUDE (°F.) OF THE HISTORICAL CLIMATIC FLUCTUATION SINCE T1850 IN JANUARY. DATA EXTEND TO T1947. ASTERISK INDICATES CURVE RISING AT DATA BOUNDARY

Station	Value and time of minimum	Value and time of maximum	Temperature difference
Bodo (from t1897)	28.9; t1921	30.2; t1935	+1.3
Bergen	33.4; t1850*	35.6; t1938	+2.2
Oslo	22.3; t1850*	26.4; t1938	+4.1
Stockholm	24.6; t1850*	28.0; t1939	+3.4
Copenhagen	29.1; t1855	33.4; t1939	+4.3
Edinburgh	36.3; t1850*	39.4; t1938	+3.1
Eastport (from t1903)	20.5; t1904	22.3; t1937-t1939	+1.8
New Haven	26.4; t1868	30.2; t1937	+3.8
Charleston	49.1; t1900	51.1; t1938	+2.0
Galveston (from t1902)	52.9; t1906	55.0; t1935	+2.1

TABLE 5. MAGNITUDE (°F.) OF THE HISTORICAL CLIMATIC FLUCTUATION SINCE T1850 IN JULY. DATA EXTEND TO T1947. ASTERISK INDICATES CURVE RISING OR FALLING AT DATA BOUNDARY

Station	Value and time of minimum	Value and time of maximum	Temperature difference
Bodo (from t1897)	53.6; t1913	56.8; t1943	+3.2
Bergen	57.4; t1864	58.6; t1941 and t1945*	+1.2
Oslo	61.0; t1850*	63.9; t1941	+2.9
Stockholm	61.7; t1890	64.0; t1947*	+2.3
Copenhagen	61.0; t1867	63.7; t1948*	+2.7
Edinburgh	58.1; t1908	58.6; t1947*	+0.5
Eastport (from t1903)	59.2; t1926	60.1; t1903*	−0.9
New Haven	71.4; t1860-t1862 71.1; t1908-t1911	72.5; t1883	+1.1 −1.4
Charleston	81.3; t1867-t1869 80.1; t1916-t1933	82.6; t1887	+1.3 −2.5
Galveston (from t1902)	82.6; t1915-t1932	83.3; t1902*	−0.7

1. Rising winter trends generally began before t1850 at several northern stations, but not until after t1900 in the lower latitudes of the United States, all the rises culminating rather near t1938.

2. Summer patterns are less distinct. There is some indication that

while temperatures were rising in northwestern Europe, reverse trends were felt in the southeastern part of the United States. Since about t1932, however, curves have been on the upswing at most stations.

The magnitudes (from less than 1°F. to over 4°F.) encountered in this discussion of 30-year overlapping means emphasize that care must be exercised in choosing 30-year means for use as climatological "normals". This problem has been considered from a statistical viewpoint by Lenhard and Baum (1954), who explore the significance of normal monthly temperatures. They conclude that the choice of an appropriate normal will depend upon the use to which it is to be put.

In addition to the references to fluctuations in climatological series mentioned above, the reader is referred to the following writers and their recent detailed investigations: *Sweden:* Angstrom (1939), Liljequist (1943; 1949), Lindholm (1955), and Wallén and Ahlmann (1954); *Finland:* Angervo (1948), and Keranen (1952); *England:* Glasspoole (1955), and Manley (1946); *Western Europe:* Schove (1950a; 1950b; 1954); *Iceland:* Eythorsson (1949); *Canada:* Longley (1954a; 1954b); *United States:* Conover (1953), Dightman and Beatty (1952), Dingle (1955), Kincer (1933; 1940), Landsberg (1949; 1951), Page (1937), Thom (1952), and de Veaux (1955); *Mexico:* Wallén (1955); *Trans-Atlantic:* Callendar (1955) and Manley (1954).

OTHER INDICATORS OF CLIMATIC FLUCTUATIONS

No exaggerated claims of "revolutionary" changes in climate (Baxter, 1953) need be invoked to demonstrate the far-reaching, and at times dramatic, events that are caused either directly or indirectly by climatic fluctuations.

It is impossible to present here a complete review of recent literature along these lines; only an outline of the diverse effects can be suggested. It is hoped that the references will aid the reader in investigating the various topics at his leisure.

Probably the most widely-recognized effect of the amelioration in high latitudes is the northward migration of the cod (*Gadus callarias*) along the western coast of Greenland (Hansen, 1949; Lee, 1949; Rollefsen, 1949; Taning, 1949). It has become a staple of the west Greenlander's diet and is a factor in the initiation of social reforms in the country.

Close attention is being given to the possible physical causes of marine migrations through consideration of what has been called "the climatic change in the sea" (Brown, 1953; Dunbar, 1951, 1954; Helland-Hansen, 1949; Segerstrale, 1950; Smed, 1949). Investigations from both physical and biological viewpoints have been made on the conditions in the southern North Sea during the severe winter of 1946-1947 (Simpson, 1953; Vaux, 1953). Generalizations based on such detailed investigations of a single amomalous event will help throw light on the long-range effects of climatic fluctuations.

The extent and duration of sea ice is intimately interrelated with climate (Schell, 1952; 1956), changes of the ice being both cause and effect of climatic variation. Koch (1946) has investigated the east Greeland ice. Jurva (1952), Palosuo (1950; 1953) and Wallén and Ahlmann (1954) present reports on ice conditions in the Baltic Sea, with emphasis on the response of sea ice to climatic control. Probably the most marked change in the duration of sea ice has occurred in the Svalbard area, where the shipping season has increased four months, from about three at the turn of the century to seven in 1940.

Animal migrations have, of course, taken place on the land as well as in the sea during recent years (Erkamo, 1952a, 1952b; Fridriksson, 1949; Halme, 1952; Jespersen, 1949; Kalela, 1952; Nordman, 1952; Siivonen, 1952). Finnish contributions on the influence of a changing climate on forest cover and crop yields illustrate the importance of climatic fluctuations in regions of marginal biological environment (Hustich, 1948, 1949, 1951, 1952; Mikola, 1952). Timber lines (Griggs, 1937) and tree rings (Müller-Stoll, 1951; Schove, 1950b, 1954; Schulman, 1951, 1953) are indicators of climatic change, the latter frequently providing useful information for the period before man's recorded observations.

Glacial geology is usually regarded as providing information about climatic variations of time orders III and IV. However, glacier observations, especially during the last 100 years, contribute greatly to knowledge of the cumulative effects of climatic fluctuations (Ahlmann, 1946, 1948b; Flint, 1947, 1951, 1953; Lawrence, 1950, 1952). Systematic glaciological observations have recently been undertaken at several locations (*e.g.*, Orvig, 1954; Wallén, 1948, 1949). Permanent snow beds, because of their formation in marginal areas under climatic conditions critical to their survival, offer valuable information for study of climatic change.

From review of these geophysical and geobiological phenomena, two important deductions can be made:

1. The indicators synthesize climatological elements and respond to both climatic influences and stimuli of a non-climatic nature. The isolation of the climatic and non-climatic controls constitutes a basic major problem in the study of climatic-change effects.

2. Phenomena respond to climatic-change influences with unique

lag periods. It would appear that knowledge of the length of these periods, coupled with an understanding of recent climatic fluctuations, could be used as a predictor of specific phenomena, with resulting economic benefits.

AN IMMEDIATE CAUSE: THE GENERAL ATMOSPHERIC CIRCULATION

The winds that brush the surface of the Earth frequently appear to do so in a relatively haphazard manner, even when the surface pressure patterns are delineated as on the commonly-presented weather map. However, as one progresses only a few thousand feet upward through the atmosphere, the winds take on more ordered directions. Many of the surface cyclonic (counter-clockwise in the northern hemisphere) and anticyclonic swirls disappear with height. In middle latitudes, the "inconstant" surface winds coalesce to form the "prevailing westerlies," a broad and deep, undulating current of air circling the North Pole in a gigantic vortex (Byers, 1954; Hare, 1953; Namias, 1952a, 1952b; Rossby, 1951; Wexler, 1955).

This westerly current flows around the northern hemisphere in an undulating fashion and, like its earth-bound analogue, an old meandering river, it occasionally forms cut-offs. Cyclonic cut-offs separate from the main stream in low latitudes, while their anticyclonic counterparts form from the northern meanders. These high-latitude features appear to be of special importance in the study of temperature anomalies.

The atmosphere has frequently been compared to a huge heat engine, receiving its energy from the sun (*e.g.*, C. E. P. Brooks, 1953). If the atmosphere were not a fluid, the equatorial regions would reach extremely high temperatures before attainment of radiative equilibrium, while the temperature at the poles would plummet toward absolute zero during the polar night. The atmosphere and oceans—fluids in motion—account for the comparatively narrow limits of temperature experienced on Earth. The atmosphere is always seeking to transport warm air northward and cold air southward; only the rotation of the planet prevents the formation of one large meridional cell of circulation.

The meandering circumpolar westerlies, therefore, are driven by the difference in temperature between the equator and the pole, and owe their direction to the rotation of the Earth. A large exchange of air will take place when the generally westerly flow exhibits many meanders.

Studies conducted on the northern cut-offs ("blocking highs") have shown that, when established, they are relatively stable features of the general circulation (Rex, 1950) and that the weather associated with them is usually abnormal (Wallén, 1953). Through application of this physical model of the blocking high, we have a valid reason to expect (say) monthly anomalies in certain climatological elements. It only requires an extension of this argument in time to offer a reasonable immediate cause for one phase of a climatic fluctuation. Other special states of the atmospheric circulation may, of course, also play a role in the fluctuations.

If we again resort to the analogy of the heat engine, it is to be expected that one "stroke" will have been completed at some time. This is also valid for the atmosphere. For, as the meridional circulation "speeds up" to reduce the latitudinal temperature gradient, it destroys the very reason for its existence. The meridional circulation slows in response to a decreased temperature gradient and, of course, will not increase again until the gradient strengthens. Pulsations in this mechanism are probably the main *immediate* causes of climatic fluctuations of time order I (Mather, 1954; Petterssen, 1949).

Contemporaneous fluctuations in the general circulation of the atmosphere cannot be regarded as the *ultimate* cause of a climatic fluctuation. It is logical to turn to consideration of the sun, as the source of essentially all energy, in seeking the ultimate cause. Recent meteorological research, particularly by Willett (1949; 1951; 1953) is not conclusive but offers possible approaches to the problem. It is, of course, also possible that the changes in the general circulation are the result of internal characteristics of the atmospheric system which are not yet understood.

SUMMARY AND CONCLUSION

Difficulties inherent in the use of climatological series to ascertain the existence of climatic fluctuations have been outlined, and the behavior of selected series has been described with reference to the widely-discussed fluctuation of recent years. The reality of the fluctuation may be questioned from statistical considerations (v. d. Bijl, 1951), but it appears real in its effect on climate-dependent geophysical and geobiological phenomena.

The immediate cause may be found in contemporaneous fluctuations in the general circulation of the atmosphere. The ultimate cause, however, escapes positive identification.

It is perhaps appropriate to close on the optimistic note sounded by Professor Ahlmann in his Isaiah Bowman Memorial Lecture (1953): "Whatever the future may bring, we are justified in saying that of the endless series of climatic fluctuations that have occurred from the beginning of the earth and that will continue in the future, the present one is the first that we can measure, investigate, and possibly explain."

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NEW HABITATS FOR WATERFOWL

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Continued drainage and industrial encroachment on the last remnants of natural breeding and feeding grounds for waterfowl in many parts of the United States have created a serious problem in the maintenance of our continental supply of waterfowl. We have become almost completely dependent on our good neighbor, Canada, for the production of migratory species of ducks and geese. There seems to be slight hope that this trend can be reversed in the face of a rapidly increasing human population. Therefore it is extremely important that measures be promptly developed for replacing these recently destroyed waterfowl habitats by the construction of new breeding and wintering grounds for waterfowl, on sites that are readily available and are not being profitably utilized by man. It is equally important that methods be devised for the improvement of existing waterfowl areas.

SITES FOR NEW MARSHES AND PONDS

Among the sites that are available for such development in increasing numbers are abandoned gravel and clay pits, sumps for the efflux from sewage disposal plants, sewage lagoons, submarginal or abandoned farm lands, abandoned strip-mines, shrub swamps, low-grade timber swamps, semi-dry marshes and bogs.

Preliminary work at the U. S. Fish and Wildlife Service's Patuxent Research Refuge, near Laurel, Maryland, has demonstrated that valuable waterfowl habitats can be created and managed for the production and wintering of waterfowl in sites that had never been utilized by these birds. This small experimental refuge, with an area of approximately 2650 acres, is situated along the inner edge of the Atlantic coastal plain, about midway between Washington, D. C., and Baltimore, Md., with nearly 3 million people living less than 30 miles from it.

The tract that comprises the Patuxent Refuge had no waterfowl with the exception of an occasional wood duck along the narrow, wooded river channels, when that refuge was started in 1936. It consisted primarily of abandoned, worn-out farm lands that had become overgrown with low-grade pine and deciduous woods interspersed with small areas of eroding fields and brush land. Bordering the network of silt and debris-choked semi-dry channels that constitute this section of the Patuxent River, and along several tributary brooklets in this tract are fairly extensive shrub swamps and timbered swamps that had no surface water suitable for use by waterfowl. On one of these brooklets a 53-acre lake was constructed in 1938. This lake was used primarily for recreational purposes until 1944, and most of the Refuge's wildlife reesarch centered around farm-game and laboratory studies. As a result of increased need for information on the development and management of waterfowl habitats, research has gradually been extended into the latter field.

CONSTRUCTION OF IMPOUNDMENTS

At the present time 13 units in a chain of experimental impoundments, that are part of a planned series of about 20 lakes, ponds and marshes, have been completed or are under construction. This chain, in the form of an "L," is more than 4 miles long. All of these impoundments are being created on sites that are unsuitable for agriculture or other economic uses. They include shrub swamps, wooded swamps dominated by worthless trees, abandoned gravel pits, an eroding ravine, and a lagoon for the effluent from a sewage disposal plant. In addition to these impoundments on Fish and Wildlife Service's lands a series of nearly a dozen, small, iron strip-mine ponds are available for plant studies on the nearby National Agricultural Research Center. Several abandoned clay-pit ponds are similarly accessible in neighboring areas, and a large, recently-constructed, water-supply reservoir ("Rocky Gorge") on the Patuxent River, a few miles upstream from the Patuxent Refuge, is available for waterfowl management studies under a cooperative program with a local chapter of the Izaak Walton League, which is developing a waterfowl refuge on that reservoir.

Most of the Patuxent Refuge impoundments have been constructed in pairs or series. Those that are intended primarily as winter feeding grounds for ducks and geese are subjected to a biennial, partial drawdown that exposes about half of the basin during the period from mid-June until the end of the growing season, about October 1. This permits a maximum development of many kinds of valuable food-plants in sites having dark-stained, turbid or excessively acid waters, where light penetration is inadequate or chemical and physical conditions unfavorable for the growth of important submerged plants. The plants that are produced on the moist soils during the summer draw-down are usually flooded in three stages, early autumn, early winter and early spring, by a gradual replacement of the splash-boards in the water-control structures. This permits full utilization of the feed by shoal-water ducks.

A biennial draw-down is preferred to an annual de-watering because the latter procedure permits an excessive development of undesired plants that tend to choke out more valuable food-plants. When the draw-down is alternated so that a full-pool is maintained in each impoundment every other year the vigor of the pest plants is greatly retarded and much of the undesired growth eliminated during the years when the impoundments are kept completely flooded.

Correct design in the construction of water-control structures is of primary importance in the successful operation of any impoundment for waterfowl. Adequate gate and spillway capacity to handle the heaviest precipitation without any extensive build-up of water levels is essential to prevent the flooding of nests, and to forestall damage to food-plants. The impoundments have been constructed by various methods, chief among which are the dozing of low-dikes or raising the elevation of existing service roads and equipping culverts under them with a sluice-box type of reinforced concrete head-gate, designed for the installation of two sets of splash-boards. An 8-inch space between these twin sets of boards is filled with carefully packed clay or other impervious soil to prevent any loss of water. Gradually tapered soft-wood wedges are used to keep the splash-boards tight against one surface of the perpendicular slots. Key slots 4-inches deep, for the insertion of a single thickness of splash-board to retard leakage under the boards, are constructed in the concrete sills at the base of all splash-board slots. The boards are made of 2 by 8-inch, pressure-creosoted oak. They are installed in double thicknesses, with the lower half of the first board fitted into the key slot in the sill. This permits the companion tier of boards to overlap all the cracks between the "key" tier of boards.

Where roads are not involved, and low dikes are used, water-control structures consist of reinforced concrete piers and abutments equipped with splash-boards as described for the sluice-box type of structure. The interspaces between the piers and abutments, should not be greater than 4 feet to prevent undue warping of the splash-boards.

Such structures permit stabilization of water levels at any desired elevation throughout an impoundment. All structures should be provided with erosion-resistant aprons and spillways, when necessary. It has been found that a spillway lined with heavy boulders and angular chunks of stone or old concrete, serves well on moderate grades and often costs very little in comparison with poured concrete. The steeper the slope the heavier should be the stones or broken concrete used in the lining of the spillways.

Dikes are constructed of non-porous earth, or with a clay core, and should have gradual slopes, preferably not steeper than a 4 to 1 ratio of slope base to height. A thick layer of coarse gravel should be spread downward from just above the water-line to the foot of the slope to discourage burrowing, with the resultant damage, by muskrats, and to retard erosion by waves.

As soon as the dikes are completed they are mulched with ripe hay that has been produced on the refuge and stored for that purpose. We prefer a mixture of orchard grass, redtop grass and perennial rye grass for this cover. This hay is harvested during the first ten days in July, when the seed is fully ripe. The mulch retards erosion as soon as it is applied.

TURBID AND STAINED WATER

Prolonged turbidity and dark, organic stains are two widespread conditions that prevent the successful growth of most submerged plants by excluding or absorbing the necessary sunlight. Many of the best waterfowl foods cannot thrive under such conditions. If the turbid condition of the water is due to the activity of such bottom-feeding fishes as carp or catfish, only their removal will correct the problem. However, the muddy condition of many waters is due to colloidal types of clay that are stirred up by wave action or carried in by run-off from eroding hillsides, and remain in suspension indefinitely. This type of turbidity has been eliminated in our larger impoundments by increasing the carbonic acid content of the water through the submergence and decay of heavy growths of herbaceous vegetation that are produced on the emergent portions of the basin during the summer draw-down. It was found that an exposure of about half of the lake bed was necessary to produce the quantity of vegetation needed for supplying the desired amount of carbonic acid that precipitates the suspended clay.

Dark organic stains usually originate from decaying, woody debris, or the leaves from woody plants, that become submerged in the impoundments. Removal of all dead and down timber should be a primary goal in the development of such basins. The stains can often be greatly reduced by heavy applications of agricultural lime on the adjacent slopes, or spread throughout the basin. It has been noted that these additions of lime have also been helpful in eliminating turbidity caused by colloidal clay.

SEWAGE LAGOONS FOR WATERFOWL

The completion of a 7-acre basin for impounding the effluent from the filter beds of a sewage-disposal plant at Patuxent Refuge headquarters tract has supplied a testing ground for determining the value of such waste-waters in creating feeding and nesting grounds for waterfowl and other valuable forms of wildlife. The rapid increase in the use of sewage lagoons for economically and successfully solving the sewage-disposal problems of small towns in several states and the use of certain of these lagoons by large numbers of waterfowl, have been apparent for several years. During the autumn of 1955 the writer found some of the best concentrations of shoal-water ducks in North Dakota on such basins. Comparable areas, from Massachusetts to Texas, are known to be highly attractive to waterfowl.

Preliminary findings, based on the first season's observations at the Patuxent lagoon, which varies from 1 to 3 feet in depth, are encouraging. This lagoon was created by dozing a low dike around a semi-swampy section of an old field that had become extensively overgrown by a 10 to 20 year old stand of sweetgum and red maple intermingled with dense greenbrier and poison ivy vines. This woody growth was removed by bulldozers before the dike and shallow basin were constructed. During early May, agricultural lime (hydrated) was spread at a rate of about 2 tons per acre on the previously mulched dike, and on a series of 6 low islands that had been constructed across the entire length of the lagoon. Finely ground limestone was applied at a similar rate to about 10 acres of a gently sloping watershed that drains into the south side of the basin.

This lime was applied for two primary purposes: to improve the soil for the production of forage grasses and clover, and to test the practicability of clearing certain types of muddy water by the gradual introduction of lime which would be carried into the basin by rain and melting snow. The original water in small pools in the site of the sewage lagoon was decidedly acid, having a pH rating of 5.2 to 5.7, and is partly supplied by acid spring-water and partly by surface run-off from acid soils on a watershed with an area of 25 to 30 acres. This original water had remained constantly turbid with colloidal clay, apparently brought into suspension by the activities of an acid-tolerant crayfish (*Cambarus diogenes*). The new basin was filled during March and the acid condition was soon corrected as the fertile effluent from the sewage disposal plant mixed with the spring water and the surface water from the adjacent hillside. The pH rating had improved from a low of 5.2 to a high of 8.3 by the middle of the summer and then gradually dropped back to near the neutrality point by the middle of the winter as cold weather reduced the consumption of carbon dioxide by the algae and other aquatic plants. A drought prevailed during the first half and middle of the summer and the water remained very muddy in spite of the improved pH. This lack of rainfall prevented most of the lime that had been spread on the islands and bordering slopes from being carried into the basin. Heavy rains, starting on August 11 and continuing at frequent intervals during the remainder of the growing season, soon carried increasing quantities of the lime into this basin, precipitating the colloidal clay and leaving the water clear enough so that the bottom was visible throughout the entire impoundment during the following winter.

The fertilizing effect of the increased nitrogen and phosphorus from the sewage-disposal effluent stimulates a heavy production of certain types of green algae, that would gradually exclude the necessary sunlight from valuable, submerged seed plants. While this excess of fertilizing elements is desirable for the production of most marsh plants, the accompanying algal growth can be a serious handicap to many important, under-water duck foods. To control this the inlet channel from the sewage filter beds has been modified so that the effluent can be easily excluded from the lagoon and diverted into its former channel to the Patuxent River whenever desired.

Nine species of aquatic plants and 17 kinds of marsh plants that are important as duck foods are being tested in this impoundment at the presnt time. The following food-plants appear to be well adapted for growth in sewage lagoons: squarestem spikerush (*Eleocharis quadrangulata*), hardstem bulrush (*Scirpus acutus*), softstem bulrush (*Scirpus validus*), wildrice (*Zizania aquatica*), rice cutgrass (*Leersia oryzoides*), wild-millet (*Echinochloa crusgalli*), arrowhead (*Sagittaria latifolia*), dotted smartweed (*Polygonum punctatum*), largeseed smartweed (*P. pensylvanicum*), waterpepper (*P. hydropiper*), Asiatic dayflower (*Aneilema keisak*), spatterdock (*Nuphar advena*), floating-leaf pondweed (*Potamogeton natans*) and duckweed (*Lemna minor*). The hardstem bulrush was the most wide-spread and luxuriant marsh plant noted in the Mid-western sewage lagoons that were used for handling the complete load of sewage without any prior treatment.

In addition to the seeds of the aforementioned plants many types of aquatic insects supply important sources of food for ducks in these impoundments. The midge larvae (Chironomidae) are among the most abundant and valuable items in this category. The larvae of the drone-fly (*Eristalis tenax*) also form a useful source of food in the raw-sewage lagoons.

ABANDONED GRAVEL PITS FOR WATERFOWL

Two abandoned gravel pits are in the process of experimentation for waterfowl development at the Patuxent Refuge. One of these was used for the experimental conversion of a common cattail (*Typha latifolia*) marsh to a wildrice marsh. The cattail was mowed at ground level or under water, in mid July, when the fruiting spikes were about two-thirds grown. A second mowing was made about a month later, when the sparse new growth had attained a height of 2 to 3 feet. Freshly harvested wildrice seeds, from a Maryland tidal marsh, were broadcast on the mowed cattail plot early in the following September and made an excellent production for two years. The third year an excessive number of wildrice seedlings caused a runty stand, and a destructive leaf fungus (*Helminthosporium*, probably *oryzae*) nearly eliminated the bed.

A dense bed of the common cattail in another gravel-pit pond was destroyed by a heavy infestation of stem-boring "cutworm" (*Arzama* sp.). This pond was then planted with watershield (*Brasenia schreberi*) which has continued to thrive for many years. This gravel pit has recently been equipped with a water-gate, and water is being diverted into it from an adjacent timbered swamp. A considerable number of useful duck-foods including rice cutgrass, fall panicgrass (*Panicum dichotomiflorum*), tufted panicgrass (*P. agrostoides*), wild-millet, weak bulrush (*Scirpus debilis*), largeseed smartweed and burreed (*Sparganium americanum*) are thriving in this impoundment at the present time. In spite of the fact that the gravel pit impoundments are in the preliminary phases of development, Canada geese, black ducks, mallards, ring-necked ducks and wood ducks have used them this season, and wood ducks have nested for several years in the one equipped with nest boxes.

SHRUB SWAMPS AND WOODED SWAMPS FOR WATERFOWL

Most of the Patuxent Refuge impoundments have been created on sites that originally were an intermingling of shrub swamps and waterlogged, low-grade woodlands. The valuable timber was harvested and much of it was utilized in the construction of refuge buildings. Worthless trees and shrubs were felled, piled and burned to create the openings that have been developed into some of our most valuable feeding and nesting grounds for waterfowl by means of the biennial summer draw-down.

A recently diked swamp has been divided into units which will permit the maintenance of one section for the production, and winter-flooding, of mast-producing trees and certain valuable shrubs that furnish large quantities of attractive feed for black ducks, mallards and wood ducks. Adjacent units are being cleared for the development of marshes and shallow, open waters. Among the woody plants that have outstanding value as a source of duck food are the pin oak (*Quercus palustris*), willow oak (*Quercus phellos*), blue beech (*Carpinus caroliniana*), black gum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), winter berry (*Ilex verticillata* and related swamp species), swamp dogwood (*Cornus amomum*), and on the well-drained islands or borders the common beech (*Fagus grandifolia*). On the latter sites the smaller acorns of the white oak (*Quercus alba*) are also eaten in large numbers by mallards, blacks and wood ducks.

Two large-seeded sedges, *Carex folliculata* and *C. intumescens*, form important sources of shoal-water duck-food, as an under-story, in the flooded, woodland impoundments and in semi-open spots in the flooded shrub swamps. The big beakrush (*Rhynchospora corniculata*) and mermaid-weed (*Proserpinaca palustris*) likewise furnish useful crops of seeds in the semi-shaded sections of the flooded woodlands.

In recent clearings in the shrub-swamp impoundments, the tearthumbs (*Polygonum sagittatum* and *P. arifolium*), swamp smartweed (*Polygonum hydropiperoides*), dotted smartweed, burreed and spatterdock supply attractive feeding grounds during the flooded seasons. Early in the summer, the manna-grass (*Glyceria striata*) furnishes an abundant supply of seeds in these sites. The biennial summer draw-down is particularly important for maintaining the productivity of such impoundments. The continued use of this type of management speeds up the disintegration of fibrous or woody mats that cover most of the basins when they are flooded. The decomposition of such material is very rapid during the emergent periods, leaving the basins in a steadily improving condition for the production of such outstanding duck foods as the red-rooted sedge (*Cyperus erythrorhizos*), whose dense films of minute seeds remain buoyant throughout an entire year and are available as feed for shoal-water ducks in situations where very little other feed is accessible to such waterfowl. Open holes in the frozen surface of deep impoundments are often covered by these floating seeds. Other important waterfowl foods that thrive on such acid basins are the warty-seeded panicgrass (*Panicum verrucosum*), fall panicgrass, rice cutgrass, wildmillet, weak bulrush, and dotted, swamp, and largeseed smartweeds. The smartweed seeds often remain usable as food for at least two years if they are kept submerged.

While an increased quantity of food for wintering waterfowl in acid, dark-stained or turbid areas is produced by the summer draw-down, this system does not create optimum conditions for nesting waterfowl. For this reason the impoundments are constructed in pairs, or subdivided into units, so that one unit can be kept stabilized at full-pool stage for breeding wtaerfowl while the level of the adjacent unit is lowered to produce the maximum supply of food. If the water in a pond or lake is clear and not excessively acid, and if the depth and bottom are suitable, a stabilized level is preferred for production of well known types of feed, as well as for nesting. Some of the Patuxent Refuge impoundments are already maintained at constant levels and it is planned to maintain others in the same manner when existing conditions have been sufficiently improved. Among the valuable duck foods produced in the moderately acid waters of such impoundments are the floatingleaf pondweed, brown-dotted pondweed (*Potamogeton pulcher*), a grass-leaved pondweed (*P. berchtoldi*), ribbonleaf pondweed (*P. epihydrus*), a dwarf pondweed (*P. diversifolius*), wildcelery, several bulrushes (*Scirpus* spp.), squarestem spikerush, wildrice, swamp duckpotato (*Sagittaria weatherbiana*), hairyleaf duckpotato (*S. pubescens*), southern smartweed (*Polygonum portoricense*) and other smartweeds.

Although in many localities the spatterdock and buttonbush (*Cephalanthus occidentalis*) are considered to be undesirable plants because of their tendency to choke out other valuable duck-foods, they are among the most useful plants in the Patuxent impoundments, where abundance can be controlled by regulating water depth. Both supply excellent brood-cover for young black ducks, mallards and wood ducks, and are important sources of food. The spatterdock leaves form excellent concealment for early ducklings, before any other cover develops in the open waters. Its seeds are already ripening in mid-June and it keeps on flowering and fruiting throughout the entire summer. Its seeds form an outstanding source of summer and autumn food for shoal-water ducks and attract large numbers of wintering ring-necked ducks. Myriads of Chrysomelid beetles develop on the spatterdock leaves and supply an important source of animal food for young ducks. The sheltering tangles of the flooded buttonbushes furnish an excellent escape cover, from aerial predators and from human disturbance, for young waterfowl and for molting adults, and the seeds are eaten during the winter and spring months by many kinds of ducks.

DEVELOPMENT AND MANAGEMENT OF MEADOWS FOR WATERFOWL

The creation and management of meadows in the excessively wooded region along the inner edge of the Atlantic coastal plain affords a frequently overlooked approach to the improvement of impoundments for many species of waterfowl. Techniques for the conversion of low-grade woodlands to valuable meadows, and the management of these grasslands, have received special attention at the Patuxent Refuge for several years. Because most North American waterfowl prefer the prairie marshes or similar open areas for nesting grounds, and a combination of coastal meadows and adjacent shallow waters for their wintering grounds, an effort has been made to create open grasslands along portions of the borders of all our impoundments. As evidence that this approach is worth-while, one need only point to the fact that more than 30 kinds of waterfowl have used these experimental areas during 1955.

Virginia pine woods, 25 to 40 years old, have been converted into attractive feeding grounds for Canada geese, widgeon and coots, in one year's time by the following procedure: A commercial pulp-log buyer arranged for the cutting of the trees, leaving stumps with a specified height of about 2 feet to facilitate their removal by means of a bulldozer. This pine yielded from 15 to 25 cords of pulp wood per acre and brought a price of $3.00 per cord, on the stump. The income received by the Federal treasury for this wood approximated the cost of converting the woodland to hay meadows. The stumps were dozed into ridged rows on the borders of the fields, and the branches and tops were bunched by the same means and burned.

After the stumps were removed and major holes levelled, the land was plowed by means of a heavy-duty disk-plow and then thoroughly disked. Hydrated lime was then applied at a rate of 1-ton per acre, and 5-10-5 fertilizer at a rate of 300 pounds per acre.

The first meadows were planted during late August with the following seed mixture, at a rate of 28 pounds per acre: 8 pounds of perennial ryegrass, 8 orchard grass, 4 redtop grass, 5 white clover and 3 alsike clover. Small units were seeded by means of hand-operated rotary broadcasters, and larger units by power broadcasters. The ground was then rolled with a cultipacker to embed the seeds. A few small units were planted with green-manure crops to test the value of plowing under such crops to improve fertility and texture of these impoverished mineral soils, before planting the aforementioned forage species. The green-manure crops used were crimson clover, soy beans, and a recently introduced crotalaria (*C. juncea*). The latter legume is reported to be from India, and seed was supplied by Mr. Karl E. Graetz of the U. S. Soil Conservation Service. All these soil-building crops were plowed under just after the peak of their flowering seasons. Later pasture studies of these test-plots showed an outstanding improvement in the forage plants on all of them. The crotalaria was particularly noteworthy for its rapid, mid-summer growth and its value in improving the texture of heavy soils. This species averaged about 5 feet in height when it was ready to be plowed under in mid-August, just 8 weeks after it was planted.

Recent meadows have been seeded and mulched in one operation with a manure spreader, using ripe orchard grass, perennial ryegrass and white clover hay harvested for that purpose. The shade supplied by a light layer of mulch is of primary importance in getting grass seedlings established in hot weather. The last week in August has been found to be an ideal period for this type of mulch-seeding, but similar seedings in April and early May have been satisfactory. "Mulch-seeding" should be avoided during periods when strong winds are likely to scatter dry mulch. Cultipacking is a helpful procedure to embed the mulch and cover the seeds with soil.

Usually an early-summer crop of hay is harvested from the meadows, and a second mowing is made in early September with a rotary mower that pulverizes the cut material. This permits a new tender growth to develop before the autumn flight of geese arrives, and the shredded material is left on the meadows to improve the soil. Some fertilizer is needed periodically if hay-harvests are long-continued.

Meadows that have become dominated by 'warm-weather'' grasses, such as redtop, are rejuveniated for goose grazing by disking lightly, and broadcasting a mixture of perennial ryegrass, Ladino and alsike clovers at a rate of 25 pounds of the ryegrass seed, 3 Ladino and 3 alsike clover per acre, in late August. These meadows are rolled with a cultipacker as soon as they are seeded. Weedy meadows are limed and fertilized with 10-6-4 fertilizer, and treated in the same way.

The construction of diversion terraces, to prevent gullying and sheet erosion in newly developed meadows and to collect surface run-off for maintaining water levels in impoundments, should be given careful consideration. At the Patuxent Refuge, which has an average annual precipitation of about 42 inches, it has been noted that the run-off from a ten-acre meadow will supply enough water to create and maintain a 1-acre pond in an impervious basin. Terraces with a gradient of about 1 percent are preferred for such purposes in most of our sloping meadows.

NESTING AND LOAFING SITES AND GRIT STATIONS

In addition to the erection of a considerable number of nest boxes for wood ducks which have been made the subject of a special study at the Patuxent Refuge, by Mr. Clark G. Webster, series of small nesting islands and larger loafing islands have been constructed in most of the experimental impoundments. Both types of islands have been of great value in attracting and holding waterfowl. The nesting islands were constructed after the eggs in several well-concealed nests of Canada geese along the borders of a shallow bay were destroyed by raccoons, and after packs of stray dogs had killed geese and young ducks in nesting areas.

The geese prefer small, circular islands with a crown diameter of less than 10 feet and a height of 2 to 4 feet above the maximum water level. Loafing islands of similar height, with crown dimensions of about 25 by 50 feet and very gradual slopes, seem most attractive. During 1955 four pairs of Canada geese nested successfully on small, man-made islands in one area where destruction of wood duck eggs by raccoons in nearby nest boxes was severe. Apparently the nesting Canada geese are able to defend their nests against swimming raccoons even where the small islands were located less than 50 feet from shore.

The islands have been constructed by means of a bulldozer, during the summer draw-down. On boggy soils a dragline, or similar excavator operated on mats, would be more effective in placing the islands at strategic points.

Most islands should be planted with cover-grasses. Seeding is usually accomplished by mulching the islands with ripe orchard grass and redtop. Transplantings of switchgrass (*Panicum virgatum*), using small tufts planted about 18 to 24 inches apart in squares, at scattered points on the large islands, and in the middle of the small islands, have been found especially useful for early spring nesting cover. As many as 4 pairs of mallards have nested in this type of cover on one 35 x 60 foot island.

The greatest problem in the successful use of islands for waterfowl is the destruction by wave action and by the burrowing activities of muskrats. Unless erosion by wave action can be prevented the life of most islands in wind-swept areas would be too brief to justify their construction. Where practical the islands should be constructed in areas that are sheltered by topographic features or by beds of wave-resistant vegetation. Such beds can be created by sod-plantings of hardstem bulrushes if muskrats are not unduly abundant. The larger islands can be constructed with gradual slopes, preferably having a base to height ratio of about 6 to 1, to prevent erosion. A thick layer of coarse gravel extending from just above the wave-line to the submerged base of the small islands aids greatly in retarding wave-erosion and in discouraging burrowing by muskrats. When such material is not available it may be necessary to protect the slopes along the windward water-line by a revetment of carefully placed boulders or chunks of broken concrete. In other areas buffers to break wave-action can be made of logs, wide-bound bundles of slender willows or similar material, fastened between pairs of steel posts or durable stakes driven into the soil a few feet out from the windward slope of the island.

Grit stations, supplied with fine gravel and cracked oyster shells, have been established at convenient points along the shores. The latter material is of special importance for resident waterfowl in a lime-deficient region like that prevailing in our experimental area.

PREDATOR AND DISTURBANCE PROBLEMS

Predation is a major problem at the Patuxent Refuge for all nesting waterfowl. The principal egg-destroyers are the raccoons and crows. Among the predators on ducklings, large black bass, chain pickerel and snapping turtles have caused the greatest destruction. Packs of stray dogs also are a frequent problem, killing both adult and young Canada geese which the parent geese were attempting to defend. Pilot blacksnakes and mink have occasionally entered the wood duck nest boxes, and devoured the eggs. Competition for nesting sites by starlings is a major problem in the wood duck boxes.

The off-shore placement of these boxes has prevented similar competition from gray and flying squirrels.

Depredations on mallard nests, by resident crows, began on March 19 this past year, on one impoundment, and were permitted to continue until early May. Every one of the nests was robbed, even though well concealed, and nearly 100 damaged eggs, from at least 8 nests were found nearby. Crows were seen flying with eggs in their beaks throughout that period.

Selective control was accomplished by means of judiciously placed, carefully marked strychnine-treated chicken eggs or abandoned duck eggs from pilfered nests for bait. The treated eggs were placed in "dummy" nests, constructed on island sites that were inaccessible to wandering dogs or man. The word "poison" was written as a precaution, with a pencil on each egg. A little more than one cubic centimeter of the albumen was removed by drilling a small hole into one end of the egg and withdrawing the desired quantity of "egg-white" by means of 5 cc. hypodermic syringe. A sweetened water-solution of strychnine for the treatment of about 40 eggs was prepared in the following manner: 3 cc. of strychnine crystals were dissolved in 40 cc. of hot water to which a heaping teaspoon of sugar or a little saccharin had been added to counteract some of the bitter taste of the strychnine. The mixture was stirred and heated gently until all crystals were dissolved. Then 1 cc. of this solution was injected into the center of the egg, through the opened end and the opening sealed with collodion or a small square of Scotch tape. Such treated eggs afford highly selective control if placed in the pilfered nests or in artificial nests constructed nearby.

After this control was completed more than half of the mallard hens re-nested and produced successful broods. Then the ducklings on this pond began to disappear at a rate of one a day and it was assumed that snapping turtles were feeding on them, because those turtles had been found devouring ducklings in that area during previous years. Intensive trapipng had removed a considerable number of the turtles during 1954. The turtle traps were set again as soon as the ducklings began to disappear in May 1955 and the traps carefully tended for several weeks, but no turtles were caught. Two 18-inch and several 15 to 17-inch largemouth black bass were caught by fishermen in that area during early June, but it was not until a 19¾-inch bass was caught on June 12 that the ducklings stopped disappearing. One mallard hen that produced a brood of 16 on June 27 brought 14 of them through to full-flight stage in the same area. Several smaller broods had comparable success after the removal of the large bass.

The biennial, partial draw-down of our larger impoundments has stimulated a great increase in the production and accessibility of fish-food, with a resultant amazing rate of growth for all the fish, including the predatory bass and pickerel. Largemouth bass attained weights up to 9 pounds and chain pickerel 5 to nearly 6 pounds. Under these conditions scarcely a duckling grew to maturity, and it was not until the lake was almost completely drained and these fish removed that a good rate of survival of the ducklings was restored.

The prevention of human disturbance on the experimental impoundments has been one of the most important fatcors in the increased use of those areas by waterfowl. Such disturbance, particularly during the breeding season and during severe freezing weather when the ducks are working actively to keep a feeding area open in an otherwise ice-coated impoundment, can be more disastrous than all the damage by predators. Constant watch must be kept to guard against such damage.

WATERFOWL OF THE PATUXENT REFUGE

A dozen wild Canada geese were trapped at the Blackwater Refuge and released on the Patuexnt Refuge 10 years ago. Half of these were pinioned and the others were wing-clipped; a similar introduction was made a few years later. These have gradually increased to a resident flock of about 40 geese at the present time. Four pairs of these geese, that are capable of full flight, nested successfully on two impoundments during 1955, but one brood of goslings was killed by a pack of dogs. These geese attract a winter population that totals several hundred, and at the present time includes a wintering blue goose and Hutchins geese.

Black ducks and mallards were established as nesting species by releasing a few ducklings (hatched under a domestic duck and in an incubator) at the age of 5 to 6 weeks, in suitable environments.

Recent, similar tests with a small number of gadwall and blue-winged teal, hatched from wild eggs, have given encouraging results and will be repeated.

A wintering waterfowl population varying from about 300 to 1300 during the mid-winter season is present on the Patuxent Refuge. This population usually increases considerably in the early spring. The principal species are the ring-necked duck, mallard, black duck and Canada geese, in the order named. The following birds have used the experimental impoundments on that refuge during 1955: common loon, horned grebe, pied-billed grebe, double-crested cormorant, great blue heron, American egret, little blue heron, green heron, black-crowned night heron, American bittern, least bittern, wood ibis, whistling swan, Canada goose, Hutchins' goose, blue goose, mallard, black duck, gadwall, pintail, green-winged teal, blue-winged teal, baldpate, shoveller, wood duck, redhead, ring-necked duck, canvasback, lesser scaup duck, American golden-eye, buffle-head, old-squaw, ruddy duck, hooded merganser, American merganser, red-breasted merganser, bald eagle, osprey, king rail, sora, Florida gallinule, coot, killdeer, woodcock, Wilson's snipe, spotted sandpiper, solitary sandpiper, greater yellow-legs, lesser yellow-legs, least sandpiper, dowitcher, semi-palmated sandpiper, Northern phalarope, ring-billed gull, common tern, least tern, Caspian tern, black tern, belted kingfisher, long-billed marsh wren, red-wing, rusty blackbird.

In addition to these 61 species, many other kinds of birds are attracted to the moist borders of these impoundments.

Our water and marsh areas under development are still small, but as these are increased and developed we have every reason to hope that this small demonstration of the way waste-water can be utilized on waste-land to create favorable habitats for waterfowl will pave the way for widespread use of such areas for these valuable birds.

SUMMARY

Continued drainage and industrial encroachment on the rapidly dwindling natural breeding grounds for waterfowl in the United States have created an urgent need for a program designed to replace these areas.

A study has been in progress for several years, at the Patuxent Research Refuge near Laurel, Maryland to develop methods whereby waste waters can be utilized on widely available waste lands to create and manage entirely new areas for waterfowl.

The methods used in this experimental study are described and the results discussed.

More than 60 kinds of shore birds, marsh birds and waterfowl, including 20 species of ducks, 3 kinds of geese and whistling swans have utilized the experimental impoundments at this Refuge during 1955, in an area that had practically no waterfowl habitat a few years ago.

DISCUSSION

MR. BORALL [Oklahoma City, Oklahoma]: I would like to ask Dr. Uhler whether you have anything in the last few years that has not been covered in your other publications on duck foods, that you think is worthy of giving attention to?

MR. UHLER: There are. Right away I would cite the warty seeded panicgrass, the Asiatic day flower, *Aneilema keisak*, and we are using more widely things that were known as duck foods, but not considered of much significance at the time of the earlier publications.

I would still rate the smartweeds and several species or varieties of the wild millets and the rice cutgrass right up near the top of the list of species that we can use on the drawn-down basin.

MR. CLARENCE COTTAM [Texas]: It seems to me there is much value in this type of a paper in view of the fact that thousands of acres along the seaboard have rather amber-black waters that are normally sterile. If this points the way to utilize them and if Dr. Uhler has the opportunity to take about three minutes and tell us about the importance of fluctuation of water as a factor in producing this, I am sure it would be of benefit. I think one of his greatest contributions among the things he has found is the implication of fluctuating water levels.

MR. UHLER: I think this is trying to cover a lot with one little paper. I am sorry we were not able to cover that at all. But, the main principle of food production for winter waterfowl is a partial drawdown on a biannual basis. We expose 50 per cent of the bottom of these impoundments, the sustained ones, drawing down normally about the middle of June and producing the dozen or so important emergent food plants on the exposed beds.

We start bringing the water back in early October in three gradual stages so we do not deeply flood the feed that has been produced during the summertime all in one minute, because it would not then be accessible to shallow-water ducks. So, we try to bring it in at 18-inch stages until the 52-inch drawdown is restored. With the first step in early October, the next in early December, then the next one would be in February and that with our annual rainfall has been no problem and we found that in addition to making the feed available, it has on decaying, created a carbonic acid content to the water that precipitates the colloidal clay, creating clear water where a few years ago we had very muddy water. So, we have clear water by suspending the carbonic oxide content of the water, and for those of you who are chemists, the ionization problem is a factor that is responsible for the clearing. You have a positive ion on the carbonic acid and a negative charge on the clay-suspended colloidal types of clay and it produces enough carbonic acid to neutralize all these negative charges on the suspended clay to cause precipitation.

We tried doing it on a third of the lake bed and finally up to 50 per cent before we got a sufficient volume of the organic material to take care of that load. I use a biennial drawdown in order to prevent the infestation of some of the undesirable plants that do come in when we draw our impoundments down annually. That could be quite a problem so we have these impoundments constructed in pairs or series and we endeavor to keep the companion pond at full stage while the one is being partially drawn down.

MAN AS A FACTOR IN THE COASTAL ENVIRONMENT[1]

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I should like to call your attention to the function of cities in the estuarine environment. These are the habitats of man, notable among mammals for his lack of natural insulation, lack of special facilities, and for other features that make him peculiarly demanding upon his surroundings.

Cities modify part of the estuarine, swamp and salt marsh environment. The space taken by cities' areas on coastal maps is relatively unimpressive, however. One would say that the direct displacement of the environment is small indeed; Manhattan Island, Greater New York area, Greater Boston, Philadelphia, Baltimore, Norfolk, Charleston, Savannah, Jacksonville, Miami, Pensacola, Mobile, New Orleans and Galveston are small cross-hatched areas in great tan and green areas of coastal charts.

It is very difficult to secure a true estimate of the effects of these pockets of high human population and competitive activity upon the estuarine environment. The legislative picture indicates an obscuring intensity of feeling. It is always a great deal easier to know what people think is so than to make observations. Nevertheless, it is possible to isolate some experience from the histories of coastal developments that has projective value.

If we start with the small immediate effects, it may be noted that cities and industrialized areas are paved patches, and that the filled swamps upon which the seaward expansion of the community perches is quickly covered with impermeable sheets of compacted earth; with asphalt, concrete, shingles, and sheet metal. Rain that falls on such areas runs off rapidly in bursts of storm water. The earlier creek bottoms and gulleys are now part of the storm drainage system; their flow rates are more extreme, more and heavier solids are carried. The small deltas formed at their mouths are more sharply defined, but scouring and erosion is more marked, and there is a lower rate of vegetative stabilization.

This sequence is often observed. It was especially obvious during the post war building boom and urban expansion, when creeks carried much heavier soil loads from areas that had been cleared for development. The pattern is complicated, of course, by heavy developments along the harbor front itself.

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[1]In the absence of the author, this paper was read by Mr. Frank Coogan.

Cities expand into swamp areas. It is interesting to watch their extension into the salt marsh, first as waste fill, then as areas developed for commercial uses. Modern dumps are constructed so that they can be converted to useful space; the wastes are classified, mixed, and compacted for high stability.

Cities extend themselves for great distances to draw in food, water, building materials, clothing, and fuel. Our major coastal cities exploit the watersheds of major valleys; in some cases the diversion is sufficient to drastically change the character of the estuary. The diversion of a large fraction of the headwaters of the Delaware for New York City supply is, of course, a classic case.

The records of hearings in this case show the degree to which shellfish and fishery biologists have been concerned with the effects of controlled flood and diminished low water flows in estuaries.

The fact that fisheries are concerned does not, of course, diminish the need for increased water supplies in our large cities; this requirement is so great and so limiting that community uses are primary. The values of domestic and industrial water uses are much more readily demonstrated than are potential losses through deterioration of food producing or breeding areas of the affected shallows.

When waters are diverted from one watershed to another, tidal waters intrude further into the robbed estuary. This change is most marked during summer drought flows when most of the supply river is diverted for necessary domestic supplies. The estuary of the affected river is subjected to wider ranges of temperatures and salinities by such manipulation.

In diversion, we essentially manufacture unproductive underground streams. These commonly discharge with little estuarial development, closer to the sea than the parent stream. The city sewer outfall must be "downhill" from the supply. Discharge is to a more saline, deeper section, commonly beyond the marsh environment of the unmanaged river estuary. Although these sewer rivers are enriched streams of considerable magnitude, it is unlikely that the nutrients can be utilized as efficiently as they might be in the irrigation of a natural swamp area. This is obviously of more concern to mussels and shrimp than it is to man.

It is possible to gain some appreciation of what this diversion must mean when it is realized that a city of a million will use water at a rate of about 130 cfs.—which is higher than the lower summer flow rates of many of our small rivers.

When cities grow, the industries that service them must grow, too. Cities must be lighted at night, heated in the winter, and cooled in the summer. This means that electric power must be available, and that it must be generated as close to the consumer as possible. In the past few years the use of air conditioning has grown so general that summer electric power requirements in some cities exceed winter demands. To exploit the advantages of hydroelectric power generation for peak loads, necessary in a modern city's intermittent power use, dams with large storage capacities are necessary. These must be managed conservatively; that is, they mustn't run out of water in the summertime.

Some fraction of the spring flood season must be stored to insure summer power. One cannot say what effects the shortening of the spring runoff in the estuary will have upon productivity. It is fairly clear, however, that the flood waters for some years after dam construction will be less turbid, and possibly less fertile.

During low waters, power controlled flow will alter the freshness of upper tidal reaches of the rivers that they command. When power is being generated, the flows may be that of a large river—for one, two or more hours per day—in the intervals between, this diminishes to the minimum compatible with other water uses. The discharge schedule follows day and night and weather; it is less moderated by the tide than before. A well cooled city is certainly a great convenience, and the gains doubtless exceed any potential losses of marine food production in the affected tidal reaches.

Each person in the city community adds roughly four-tenths of a pound of organic matter to the water that the city translocates. About half of this organic loading is readily decomposed, and breaks down in the first few days after discharge. This, as we know, can cause conditions that are often more offensive to man than to the marine society, though the latter is often more publicized. The aesthetic and sanitary pollution of the city's immediate coastal environment produces a substantial loss of human facilities. The demands for recreational waters near large cities increases as these resources are lost.

The depression of dissolved oxygen and reducing conditions associated with the decomposition of sewage and various industrial wastes is a recognized limit to the use of water for waste removal. We are, however, committed to using water for waste disposal; it is cheap, and mechanically simple. Our densely populated cities cannot exist without sewerage. The economics of community development and growth virtually precludes the development of truly effective methods for reducing the pollution of harbors and estuaries.

Some industries also produce wastes that modify the immediate estuarine and shallow water environment; local effects may be adverse and striking. The rate of dilution in tidal areas is usually so great, however, that wide effects are much less marked than is commonly believed. It is certainly desirable to prevent pollutional damage to the shallow marine environment. In this habitat the dominant sessile population cannot escape intolerable concentrations of waste.

We should not imagine, however, that corrective efforts in waste practice will balance out other changes that commonly come with growing urbanization and industrialization of the coast. As local values increase it is necessary to erect protective structures; dikes, breakwaters, and jetties. It becomes desirable to make canals and cutoffs. These change delta evolution; the patterns of sedimentation and of salinities are often shifted drastically. It is interesting that the changes that are most markedly due to man's operations come from his efforts to block the rapid changes in the shallow coastal environment that normally occur. We commit ourselves to this by unnoticed steps, fighting with increasing costs to protect the property that we cannot yield.

If we were searching for some distinguishing feature of man's activities on shallow, coastal ecology, we would first discover the large zones of translocation that sustain his cities. Man moves and mixes environment, the activities of other species are frequently intense, but changes are local. Man hastens the movement of the land to the sea.

DISCUSSION

MODERATOR PRITCHARD: Do we have any discussion from the floor of Dr. Renn's paper? Certainly, there is serious conflict between the efforts of the conservationist to utilize all of the resources of a natural environment and the problems which are related to the variety of uses. We are obtaining food from this environment and also using this same environment as a place to dispose of wastes. As Dr. Renn has said, we can't afford to eliminate this source of waste disposal completely, but we certainly should attempt to control it so it does not completely destroy the environment for other uses.

THE NUTRIA AS A WILD FUR MAMMAL IN LOUISIANA

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The nutria or coypu (*Myocastor coypus*) has been an object of much interest in the United States during the past ten years. A native of South America, hence sometimes called the South American beaver, it was first introduced into this country as a fur animal to be raised in captivity. Escapes and releases from fur ranches established feral colonies in Washington and Oregon (Larrison, 1943), California (Howard, 1952), Louisiana (Lowery, 1943), and New Mexico (Ashbrook, 1948). The trapping of wild nutria for fur, however, has become a sizable industry only in Louisiana.

Interest in the nutria occurred because the species provided a new source of fur in the United States. As the nutria population in Louisiana increased and more became known of the animal's activities, it was extolled as a biological agent for the control of unwanted vegetation in marshlands and impoundments. For these reasons feral colonies of nutria have intentionally been established in other states. On the other hand, nutria have been accused of denuding the marsh of desirable vegetation and competing with muskrats in the coastal regions of Louisiana.

Because of this interest in the nutria, popular articles have been written giving size and reproductive data derived from captive animals. Little has been published on feral nutria populations in the United States. The purpose of this paper is, therefore, to give something of the present status of the nutria in Louisiana and to record weight, measurement and reproductive data for feral nutria in southwestern Louisiana.

The writer wishes to acknowledge the cooperation of the managers and trappers of Louisiana Fur Corporation and Lacassine National Wildlife Refuge in the collection of the data. The advice of Frank G. Ashbrook in preparing the manuscript is greatly appreciated. Thanks are due Earl L. Atwood for suggestions and data which he made available for comparisons.

THE NUTRIA IN LOUISIANA

Nutrias were first brought into Louisiana from Argentina by E. A. McIlhenny in March, 1938, and were placed in a fenced area where they increased rapidly. It is probable that a few nutrias soon dug out of the enclosure, but many more escaped into the surrounding marshland during a hurricane in 1940. The marshes provided suitable habitat, for they increased in numbers and dispersed widely by means of the network of canals, bayous, lakes and other waterways in the coastal marshes. By 1946 nutrias occurred from the west bank of the Mississippi River into southwestern Texas (Dozier, 1951). Since then extension of range along the Gulf Coast from Galveston Bay, Texas into Florida and northward into eastern Texas, northwestern Louisiana and southwestern Arkansas was brought about largely by intentional releases. In Louisiana nutrias are most abundant in St. Mary, Iberia, Vermilion and eastern Cameron Parishes.

Annual catch records of fur animals (mimeographed release by the Louisiana Wild Life and Fisheries Commission) give an idea of the increase of nutria in Louisiana. Severance tax was paid on 436 nutria pelts taken during the 1943-44 trapping season, whereas eleven years later (1954-55 season) the tax was paid on 374,199 pelts. The actual catch was considerably higher than these figures indicate, for many nutrias are discarded in the marsh and many are killed to protect rice fields.

It is fortunate that the nutria increased during a period of declining muskrat populations. Many trappers have thus been able to continue their trade of trapping in the marshlands. However, the nutria has not found complete favor with most of these trappers. Much labor is involved in bringing the pelts to the trappers' camps and in scraping, stretching and drying them. Trappers can skin and stretch the pelts of 10 to 20 muskrats in the time it takes to handle a single nutria. Furthermore, the fur buyers' standards are high for nutria pelts. Only well-handled, well-furred skins 23 inches or more in length are accepted, and this minimum length may be increased to 26 inches. Consequently, small animals and those with flat or damaged pelts are discarded in the marsh. The average price of $1.50 to $2.00, received for each pelt during the past several years barely provides a profit to the trapper for his share of the season's catch. Most trappers do not own the land which they trap and usually receive 60 to 65 per cent of the pelts.

Further, the nutria market in this country is limited. Most of the raw pelts taken are exported. According to F. G. Ashbrook (U. S. Fish and Wildlife Service mimeographed release, 7-1-55), this situation is due to the high cost of processing nutria pelts and manufacturing fur garments. Prices paid for raw nutria pelts are not likely to increase until these costs are reduced or the market is expanded in countries where processing and manufacturing costs are lower than in the United States.

The ecological impact of the nutria on the coastal marshes of Louisiana is not yet clearly known. So far, the activities of the nutria in denuding marsh vegetation has been beneficial to certain ducks (personal communication from John Lynch, U. S. Fish and Wildlife Service). Where populations of nutria are high, they have been accused of wide-spread destruction to marsh vegetation. This situation, however, is confused with the effects of drouth during recent years and with other changes in marsh ecology. At present, this problem is being studied by the U. S. Fish and Wildlife Service in collaboration with the Louisiana Wild Life and Fisheries Commission.

Nutrias are also accused of competing with muskrats and preventing their increase. It is said that nutrias break down muskrat houses and drive the muskrats away. Although nutrias do climb upon muskrat houses, as evidenced by their droppings, my data do not indicate that this results in damage to many of the houses. There is some evidence, however, that nutrias relish Olney's three-square (*Scirpus olneyi*), the principal food plant of the muskrat in Louisiana. Thus, competition for food occurs.

Where agricultural land lies adjacent to marsh land, canals and other waterways, nutrias have attacked farm crops (Ensminger, 1955). Nutrias have damaged rice fields in particular by digging in or through levees and by cutting the rice. Through feeding and platform-building, openings up to 50 feet in diameter have been created. This damage requires constant vigilance and control by rice farmers in some regions.

There is no reliable data on the numbers of nutria inhabiting a marsh area in Louisiana. For one reason, nutria seem to move from place to place, responding to water levels and food availability. To provide some notion of their density, I have estimated populations on the basis of the number of pelts taken. Such estimates have indicated between three and four nutria per acre on heavily populated trapping units. This amounts to a biomass of 30 to 40 pounds.

Sampling the Nutria Population

To provide additional knowledge about this exotic fur animal, feral populations of nutria in Vermilion and northeastern Cameron Parishes were sampled to obtain weight, measurement and reproductive data. A complete day's catch formed the unit sample in order to represent the population as fully as possible. A complete day's catch of nutria is not easy to obtain. Almost all trappers skin and discard the nutria carcasses in the marsh. Also the catch is culled as the trapper makes his rounds, small nutria and those with flat or damaged pelts being discarded. It is difficult to follow the trapper about and obtain the desired data without impeding his activities. Three trappers, who made their rounds largely by boat, cooperated by bringing in their total catch.

The data herein reported are based on five complete, daily catches made during January and February, 1955. They comprise records on 232 nutria. The nutria were taken in the following localities: (1) A total catch for two days on Six-mile Canal, Vermilion Parish, Louisiana, representing a brackish to fresh water marsh; (2) A single day's catch on the west Cheniere au Tigre Canal, Vermilion Parish, Louisiana, representing a brackish water marsh; and (3) A total catch for two days on Unit 4, Lacassine Wildlife Refuge, Cameron Parish, Louisiana, representing a fresh water marsh.

Data are also available from 44 nutria taken near Belle Isle, Vermilion Parish, Louisiana, from June, 1954 to May, 1955.

Weights were estimated to the nearest two ounces. Measurements were made to the nearest ¼ inch or 5 millimeters, except that hind foot length was taken to the nearest ⅛ inch.

The smaller juvenile nutrias are not represented in these records. Although a juvenile nutria is active 24 hours after birth, its movements are probably limited and its weight is not sufficient to spring many of the traps.

WEIGHTS OF NUTRIA

For ranch-raised nutria the average weight of a fully grown male is about 25 pounds and of a fully grown female 16 to 17 pounds, but certain strains do not attain these weights. The male is heavier in build than the female (Walther, 1931). In a series of nutria taken during 1946-47 at Lacassine Refuge, Atwood (1950) found the largest male to weigh 18 pounds and the largest female to weigh 17.5 pounds. These weights were found to be in close agreement with Laurie's (1946) data for feral nutria in Great Britain. Among the 274 nutria in the present series, the heaviest male weighed 15 pounds, 6 ounces, and the heaviest female, 19 pounds, 4 ounces excluding the weight of 7 embryos. Thus nutrias in Louisiana rarely attain the weight of ranch-raised males.

The weights of male and female nutria did not differ statistically when compared by length classes. Length classes were used as a basis of comparison because the age of the nutria could not be determined. Walther (1931) makes no mention of differences in length between the sexes. Differences in weight and body build between sexes of nutria apparently do not exist in Louisiana. Atwood (1950) also reached this conclusion.

The weight distribution of 274 nutria is shown graphically in Figure 1. The distribution includes the weights of 231 nutria from the daily catches and of 43 additional animals, for no difference in distribution between the two groups was apparent. Weights of nutria varied from 1 pound, 10 ounces to 20 pounds, 12 ounces and were grouped into one pound weight classes. No correction was made for the weights of embryos in pregnant females.

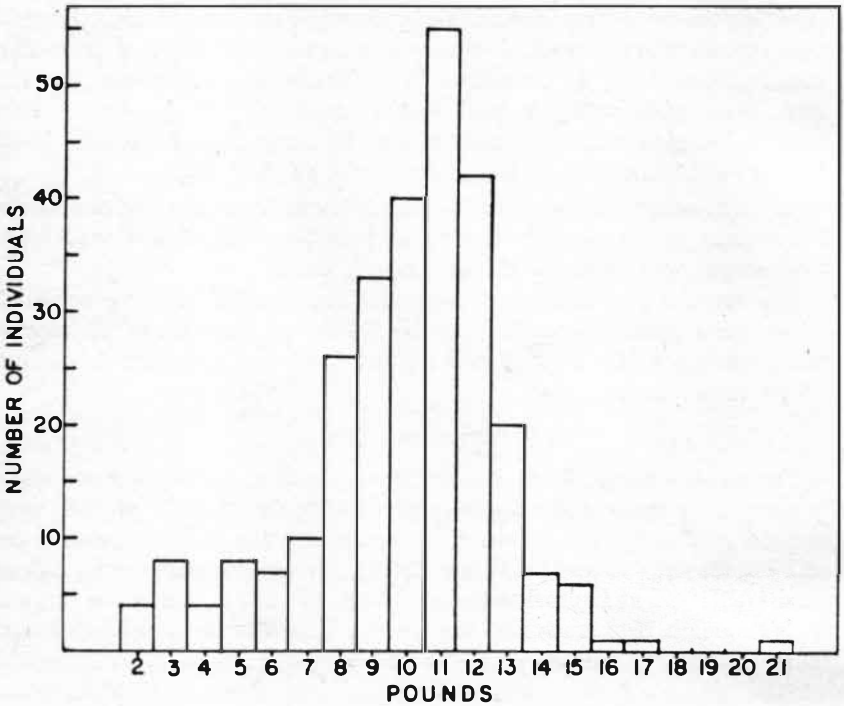

Figure 1. Weight distribution of 274 nutria trapped in southwestern Louisiana, June, 1954 to May, 1955. Class limits for the 2-pound weight class are 1 pound, 8 ounces and 2 pounds, 7 ounces.

The modal weight class of 11 pounds contains the weights of 55 nutria. The 9 to 12 pound weight classes, inclusive, represent 62.4 per cent of the nutria recorded. As mentioned, juvenile animals are not fairly represented in the sample. Further, the number of small nutria taken by trappers during the season represented by the sample (1954-55) was much fewer than during the previous season.

For comparing weights of nutria, the weights were recorded by one-inch length classes, length varying less with environmental changes than weight (Atwood, 1950). Weights of nutria from the different localities were significantly different for an occasional weight class. However, weights of nutria in one locality, when compared with weights in another locality, were not consistently higher or lower for all or most of the length classes. Significant weight differences, therefore, did not occur between nutrias from the habitats that were sampled. Significant weight differences can occur between years in nutria populations from the same area with range degeneration according to Atwood (1950).

Weights of nutrias in the same length class varied rather widely and the data, when broken down into length classes and localities are few. If nutrias vary in weight according to habitat, much more data will be required to show the differences.

The minimum raw pelt size accepted by fur buyers during the 1954-55 trapping season was 23 inches. A small amount of data indicates that the minimum marketable pelt size will be provided by a nutria weighing from 4 to 6 pounds. Laurie (1946) states that in Great Britain nutria weighing at least 6 pounds will produce skins of marketable size. She does not give the minimum stretched pelt size accepted by the fur trade in Great Britain.

MEASUREMENTS OF NUTRIA

The distribution of total lengths of 275 nutrias is plotted in Figure 2. Total lengths varied from 18¾ inches to 41½ inches, the latter being attained by 3 males and 3 females. The maximum length is not greatly different from those recorded by Atwood (1950): 43 inches for a male and 41.5 inches for a female taken during 1946-47. These lengths are also in agreement with those given for fully grown ranch-raised nutria, which attain an average body length of 24 inches and a tail length of 16 inches (Walther, 1931).

The modal class of 37 inches contains 46 total-length measurements. The total lengths of 64.7 per cent of the nutria fall into the 34 to 38 inch length classes. From a small amount of data it is estimated that a 23-inch pelt is generally obtained from a nutria measuring 28 to 29 inches in total length.

Tails of the nutrias measured from 7½ to 17⅞ inches. Tail lengths of 93 nutrias comprise the modal class of 16 inches, and the 15, 16 and 17 inch tail-length classes include 67.4 per cent of the measurements.

Body length, obtained by subtracting tail length from total length, varied from 10⅝ to 24½ inches. The modal body-length class of 30

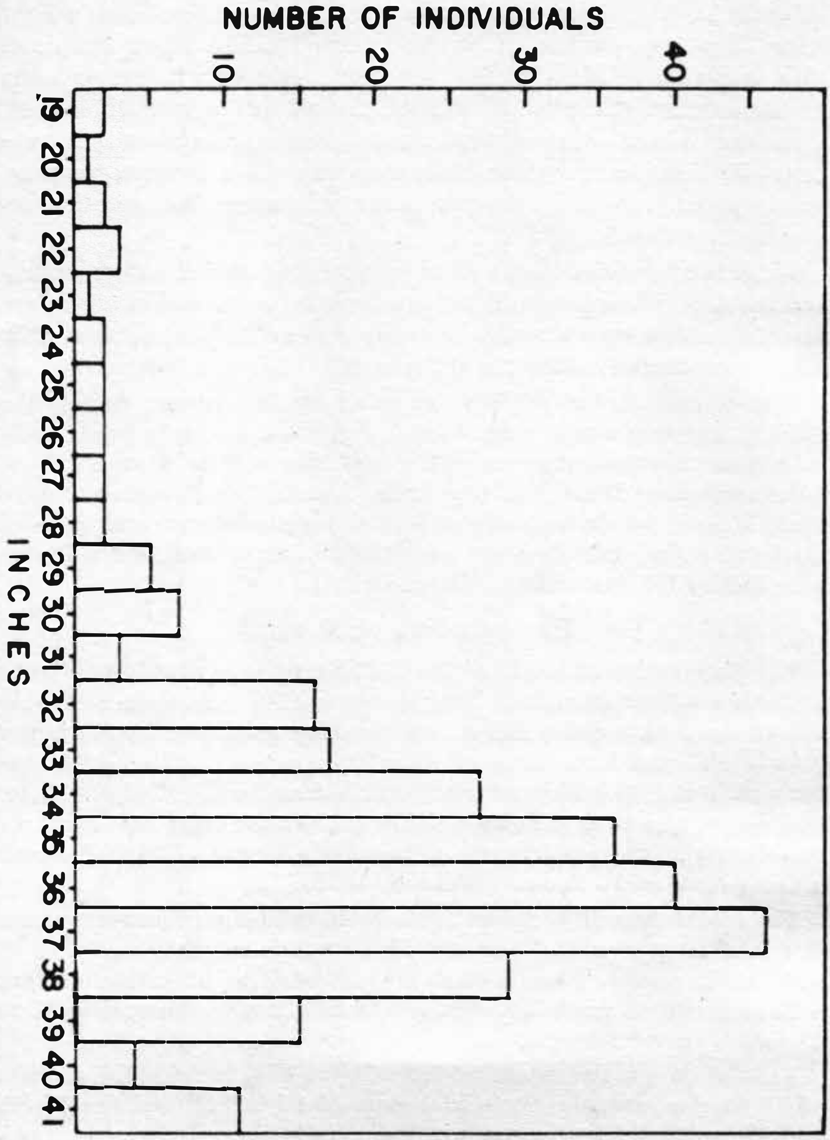

Figure 2. Total-length distribution of 275 nutria trapped in southwestern Louisiana, June, 1954 to May, 1955. Class limits for the 19-inch length class are 18⅝ and 19½ inches.

inches contains 60 measurements. Body-length classes of 19 to 21 inches include 57.9 per cent of the measurements.

Hind foot length varied from 3⅛ to 6 inches and was divided into length classes of a quarter inch. The modal class of 5½ to 5⅝ inches includes 96 measurements. The hind foot of 75 per cent of the nutria measured from 5¼ to 5⅞ inches.

BREEDING BIOLOGY

The gestation period of the nutria in South America lasts from 127 to 132 days. There are 2 litters a year or sometimes 5 litters in 2 years (Cabrera and Yepes, 1940). Laurie (1946) summarizing data on captive nutria from Great Britain and France reports a gestation period of 120 to 130 days. Dozier (unpublished data, U. S. Fish and Wildlife Service) gives 130 to 134 days for nutria at the Fur Animal Experiment Station in Maryland. Feral nutria in Louisiana breed throughout the year (Atwood, 1950).

The proportion of sexes in litters of captive nutria in Germany was found to be one to one (Walther, 1931). Among the 232 nutria taken in Louisiana there were 85.6 males per 100 females (107 males and 124 females). The deviation from a one to one ratio represented by these figures is not statistically significant. It may be noted, however, that this is in contrast to most reported sex ratios of muskrats which show an excess of males (Dozier, 1950).

The sex ratio of the daily catches varied from 60.0 to 116.7 males per 100 females. Trappers state that sometimes males predominate greatly in catches whereas at other times females predominate. Whether these variations are due to differential activity of the sexes, or whether they reflect variations due to small samples is not definitely known.

An average of 4.4 embryos per female were found in the uteri of 107 female nutria. Ninety-five of these females were taken during January and February, 1955; the remaining 12 were taken from June, 1954 to May, 1955. In South America five young is frequently an average litter size (Cabrera and Yepes, 1940). At Lacassine Refuge, Atwood (1950) found a mean embryo count of 5.6 among 35 females in 1946-47 and a mean of 4.2 among 26 females in 1947-48. Among ranched nutria in Germany the first litter averages 4 and subsequent litters average 5.5 (Walther, 1931). Thus the average litter size in Louisiana, based on embryo counts of feral nutria, is somewhat less than that of ranched nutria or nutria in their native country.

Average embryo counts for females collected from the different localities varied from 3.9 to 5.3. The low average was obtained for

24 females from west Cheniere au Tigre Canal where the marsh supports reed (*Phragmites communis*), big cordgrass (*Spartina cynosuroides*) and saltmeadow cordgrass (*S. patens*). An average of 4.5 was obtained for 46 females on the Six-mile Canal marsh which is vegetated with reed, big cordgrass, sawgrass (*Cladium jamaicense*) and Maidencane (*Panicum hemitomon*). The difference between means for these two marshes is significant at the 5 per cent level ($t = 2.178$, d.f. $= 68$). The series of 25 female nutria from Lacassine Refuge averaged 4.3 embryos. This average compares favorably with that obtained by Atwood (1950) from the Lacassine Refuge in 1947-48 but is significantly lower than his mean for the 1946-47 females ($t = 3.511$, d.f. $= 43$, prob. < 0.01). The average of 5.3 embryos was obtained for 12 females in the vicinity of Belle Isle. This series is not comparable with the others because it was collected throughout the year rather than during January and February.

The collection areas cannot now be adequately rated as to quality of habitat, nor do we have accurate figures as to the relative density of nutria on the areas. Suffice it to say that the nutria on the west Cheniere au Tigre Canal area, with a low average embryo count of 3.9, seemed to be under more ecological tension than those on the other areas. The Cheniere au Tigre series very likely sampled a high population composed of migrant as well as resident nutria. The migrant population came from an adjacent untrapped range in a serious state of vegetational depletion. To this extent the present data seem to agree with Atwood's (1950) findings of a direct relationship between fecundity and nutritional quality of the habitat.

A number of female nutria contained embryos that were disproportionate in size. From one to three embryos in these uteri were one-half or less the size of the others. These smaller embryos were examined in two uteri and found to be in the process of resorption. Thus, by external criteria, 4.7 per cent of the total embryos (22 of 471) appeared to be in the process of resorption. Resorbed embryos were present in 15.9 per cent (17) of the 107 females. Exclusion of embryos in the process of resorption reduces the average number per female to 4.2.

Atwood (1950) found one per cent resorption of embryos among his 1946-47 females and 3.5 per cent among his 1947-48 females after over-utilization of the range had increased. Females from Lacassine Refuge in 1955 show 5.5 per cent resorption (6 of 107 embryos). The number of nutria trapped on Lacassine Refuge increased from 443 during 1946-47 to 5,510 during 1954-55. The higher percentage of resorbed embryos in the nutria seems to be associated with increased populations and with vegetational deterioration.

According to Atwood (1950) puberty in nutria was attained at approximately 26 inches of total length and four months of age in 1946-47 and at approximately 29.5 inches of length and 5.5 months of age in 1947-48. The smallest female with embryos in the present series measured 29¾ inches in length. Although the reproductive tracts were not examined for evidence of puberty, the presence or absence of embryos, related to the size of the female, are in accord with Atwood's determination of puberty in 1947-48.

Among the 125 female nutria recorded in daily catches, 13 (10.4 per cent) were 29¾ inches or less in total length, and may be considered as making up the juvenile and adolescent age classes of the population. If the length criterion of puberty in females is extended to males, approximately the same proportion (10.3 per cent) of the males fall into the juvenile and adolescent age classes. It should be noted again, that juveniles are not truly represented in the catch.

Preadolescents made up 24.5 per cent of the sample (approximately 28 per cent of males and 23 per cent of females) from Lacassine Refuge. This percentage is smaller than the 35 to 40 per cent of adolescents reported by Atwood (1950) in 1946-48. However, all trappers interviewed near the areas of collection commented that many fewer small animals were being taken in 1954-55 as compared with previous years. This would suggest a decrease in the rate of growth of the nutria population in these areas. At the present time (1955-56 trapping season), trapping returns seem to substantiate this suggestion for the areas studied in Vermilion Parish.

SUMMARY

The nutria, or coypu, a rodent native to South America, was brought into the United States as a captive fur animal. Escapes and releases resulted in the establishment of feral colonies in Washington, Oregon, California, New Mexico and Louisiana. A substantial fur industry has developed only in Louisiana, where, since 1939, wild populations have increased to the extent that 374,199 pelts were taken in 1954-55. Because of Louisiana's nutria fur industry, and because the nutria tends to eliminate marsh vegetation, much interest has been shown during recent years in establishing additional feral colonies, especially in the South.

The volume of the nutria fur business is limited in this country because processing and manufacturing costs for nutria furs are high, thus limiting the retail market. Hence prices paid for raw nutria

pelts, averaging $1.50 to $2.00 each, are barely sufficient to pay the trapper's expenses and a profit for his labor.

The tendency of the nutria to eliminate marsh vegetation and the accusation that it is a serious competitor of the muskrat need further study. Nutrias cause damage to rice and other agricultural crops that lie close to aquatic habitats.

As a basis for our increasing knowledge of the feral nutria, weight, measurement and breeding data were collected from 276 individuals taken in southwestern Louisiana mostly during January and February, 1955.

The weights of male and female nutria do not differ statistically. Weights ranged to 15 pounds, 6 ounces for a male and to 19 pounds, 4 ounces for a female. Approximately 60 per cent of the nutria weighed from 8.5 to 12.5 pounds. No statistical differences were detected between weights of nutria from different marshes.

The maximum total length attained by both sexes of nutria was 41.5 inches. Approximately 65 per cent of the nutria varied in total length from 33⅝ to 38½ inches. A body length of 18⅝ to 21½ inches was attained by 58 per cent of the nutrias. The modal classes for tail length and hind foot length are 15⅝ to 16½ inches and 5½ to 5⅝ inches respectively.

The sex ratio of 232 nutria taken by trappers was 85.6 males per 100 females. An average of 4.4 embryos each was found for 107 females. Four and seven-tenths per cent of the total embryos appeared to be in the process of resorption. Resorbed embryos occurred in approximately 16 per cent of the females.

The smallest pregnant female was 29¾ inches in length, which is approximately the length at which sexual maturity is attained. Fifteen per cent of females over this length were without embryos. Approximately 10 per cent of the nutrias were under 29¾ inches in total length. Fewer small nutria were taken during the 1954-55 trapping season than during the previous seasons.

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DISCUSSION

DR. HARRIS: I might add something of a section that I left out. The ecological impact of the nutria on the marshes has been quite a problem.

With regard to damage to agriculture, these animals seem to like agricultural crops and wherever they are grown close to waterways, they get into the rice fields, corn patches, potato patches and so on and cause some damage.

Now, these things, I think, should be taken into consideration together when thought is given to the idea of introducing this animal to new areas.

DR. GALTSOFF: I would like to ask, what are the natural enemies of nutria if any?

DR. HARRIS: If any, is a good word. Farther west there is a colony established in New Mexico and there, apparently bobcats and coyotes take some nutria. In Louisiana, I don't think there is any serious predator on the adult nutria except gent vegetation such as giant cutgrass and rice cutgrass and cattail. It seems four feet in length conatined nutria, both young, and good-sized ones. Of course, the alligator population is rather low so the effect on the nutria population is practically negligible.

Aside from that, young nutria may be taken by garfish or other rough fish. Beyond that, I know of no predators.

MR. BORRELL: At one time there was quite a lot of attention given to the moving of nutria into inland ponds for the control of pond weeds. Have you made any observations on that as to whether it is completely out of the picture or whether there is still a possibility?

DR. HARRIS: I have looked over a few ponds together with the notes from the examination of my predecessor made in ponds in Texas and also in northwest Louisiana. The nutria apparently will in some situations do away with the emergent vagetation such as giant cutgrass and rice cutgrass and cattail. It seems to have no effect on the submerged vegetation. This opinion seems to be carried also by one published paper, Swank and Petrides, I believe, who wrote about the situation in Texas and also seems to be the opinion of some of the state game people in Texas.

MR. VIOSCA: Does the nutria have any effect on the alligator grass or water hyacinth?

DR. HARRIS: I can't answer that definitely. They do eat them, but I don't think to any great extent. I don't think we could hope that the nutria would help us get rid of those pests.

MR. J. L. CHAMBERLAIN [Louisiana State University]: In the early part of your paper you mentioned that at present it was difficult to separate immatures from adults and in the latter part of the paper you said you had definite figures, I believe from Larrison, on the composition of the population. How were those derived?

MR. HARRIS: What I referred to earlier, was the break down of the population into age classes, that is one-year old, two-years old, three-years old, something like that. The figures I used were those that Atwood gave. He gave a length of 29½ inches at puberty for the female nutria. I found one nutria at that length that had embryos—none under that length that had embryos. So, in order to make a rough breakdown of the older and young nutria, I just used his figures.

TECHNICAL SESSIONS

Wednesday Morning—March 7

Chairman: D. I. RASMUSSEN
In Charge, Wildlife Management, U. S. Forest Service, Ogden, Utah

Discussion Leader: ROGER A. SEAMANS
Federal Aid Coordinator, Fish and Game Service, Montpelier, Vermont

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BIG GAME RESOURCES

FLUCTUATIONS IN A DEER POPULATION IN CALIFORNIA CHAPARRAL[1]

RAYMOND F. DASMANN
Humboldt State College, Arcata, California

The study of an animal population over a period of years is useful for the understanding of mechanisms, both within the population and in the ecosystem, which lead to changes in numbers and population structure. The dynamics of big game populations, in particular, have long been of interest and concern to the wildlife manager and sportsman. Wide fluctuations have been particularly characteristic of deer populations in the United States within the past several decades, and have led to serious range damage when the population is at its peak, and to a loss of recreational values following the die-off. From 1949 to 1955 the writer has followed the build-up, decline, and subsequent levelling off of a population of Columbian black-tailed deer, *Odocoileus hemionus columbianus* (Richardson), in Lake County, California. These population changes and the factors influencing them will be discussed in this paper.

The study region is located west of Clear Lake, in northwestern California. The principal study area is approximately 400 acres in

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[1]In the absence of the author, this paper was read by Dr. Richard D. Taber.
Contribution from Federal Aid to Wildlife Restoration Project California W-31-R.

size, with vegetation consisting predominantly of ''opened brush'' (Biswell, *et al.,* 1952), an interspersion of shrubs and herbaceous vegetation resulting from the use of fire. The vegetation belongs, originally, to two major plant associations, chamise chaparral and live oak chaparral. Typically these are dense, closed-canopy assemblages of broad-sclerophyll shrubs. In fire-modified form, however, and following seeding to grass, the vegetation no longer resembles chaparral. Instead its structure is similar to woodland or savanna, with the difference that shrubs are present instead of trees. The term *shrubland* is used here to describe this vegetation, indicating an open stand of shrubs separated by a more or less continuous herbaceous ground cover. Part of the study area remains in the original dense chaparral. Other smaller areas support broad-sclerophyll forest, riparian deciduous woodland, and other plant associations.

The history of the 400-acre area before 1948 is not well known. At this time the eastern half of it had been modified through small controlled burns and grass seeding, so that it presented a patchwork of shrubland and chaparral. The western half was mostly dense chaparral except near the stream courses, where shrubland or woodland was present. In September, 1949, a wildfire swept over the country to the west and overlapped into the study area. Herbaceous cover became established in this burn with a consequent extension of the shrubland area. After 1949 the area did not burn again, with the exception of two small experimental burns which did not affect the study appreciably.

A study of the deer population in the 400-acre area is significant because shrubland of the type represented on the area is the end product achieved by chaparral management (Biswell, *et al.,* 1952). This management normally involves the use of small, controlled fires, followed by a re-seeding of the burned area to grass. If this is done the carrying capacity for deer or livestock is improved in two ways: a supply of herbaceous forage, not normally present, is made available; and the remaining brush can be kept relatively open, hedged, and within reach of animals by browsing pressure.

Early studies in this general region (Taber, 1951) showed that following wildfire burns in chaparral, when seeding to herbaceous cover was not accomplished, there is an initial rise in carrying capacity followed by a steady decline until after four or five years the carrying capacity is little higher than it was before the fire. The studies reported here show that in managed, or shrubland, areas there is also a decline in carrying capacity following the last fire, but the levelling off point is considerably higher than on an unmanaged chaparral burn.

Acknowledgments. The author wishes to acknowledge financial support received from Federal Aid to Wildlife Restoration Project California W-31-R, and in 1951-53, from the National Science Foundation. The assistance provided by Richard D. Taber, who was associated with most aspects of the study reported herein, is gratefully acknowledged. Appreciation is also expressed for the advice and assistance provided by A. Starker Leopold, and H. H. Biswell of the University of California, and by William P. Dasmann of the California Department of Fish and Game.

STUDY METHODS

Deer studies in the area were begun in 1949-50 when a pellet-group census was conducted, and a series of does were collected to determine natality and other data (Taber, 1951). In 1951, an intensive study was begun on the 400-acre area, while the gathering of comparative data on a less intensive basis was continued on surrounding areas. This study was continued until fall, 1953, and thereafter only during the summers of 1954 and 1955.

Census. Census methods used during the study have been described previously (Dasmann and Taber, 1955). In general they included for the period 1949 to 1953, pellet-group counts; from 1951 to 1955, sample-area counts; from 1952 to 1955, Lincoln-index censuses; and from 1951 to 1955, total deer counts.

The data from the total deer counts are emphasized here, giving as they do a more complete picture of the deer population and its changes. The density figures obtained by this method were found to be in close agreement with those obtained by other censuses.

Sex and age structure. Changes in sex and age structure in the population were followed primarily by the total deer counts, in which all of the deer resident in the area were regularly tallied. The methods used in separating the various sex and age classes have been described in an earlier publication (Dasmann and Taber, 1956a). Natality and fawn survival were followed by means of these regular counts during 1951-53. After 1953, when the field work was restricted to the summer, fawn survival through the year was estimated from the number of yearlings present in the summer population. In addition information on natality was obtained from two doe collections, in 1949-50 and in summer, 1953.

Of the sex and age classes shown in Table 1, the figures for the two-year-old doe class are least reliable. Except in 1951-52 when the deer groups were most carefully studied, considerable subjective judgment was used in making this classification. For two-year-old males, antler characteristics were a fairly reliable indicator of age.

Mortality. During 1951-53, changes in population structure and losses of deer from known groups were taken as indicators of mortality. The entire area was searched regularly in an effort to find the missing deer, and in most instances the carcasses were located. Outside the main study area, periodic herd composition counts gave indications of mortality, and portions of the areas were searched for carcasses. After 1953, mortality was estimated mostly from changes in population composition. Some carcass searches were conducted to determine the sex and age classes affected, but no attempt was made to find all missing deer. During hunting seasons, a checking station was maintained through which most legally killed bucks passed. In addition, hunting season mortality was determined from watching hunters in the field.

The cause of mortality was determined, when possible, by autopsy of fresh carcasses, and a search for evidence of predation. Carcasses which had rotted or dried were examined for condition of bones and bone marrow.

The results of mortality studies have been presented in part elsewhere (Taber and Dasmann, 1954; Taber and Dasmann, ms.).

Movement. Detailed studies of deer mobility were undertaken in the study region, centering on the shrubland area. The results have been presented in other papers (Dasmann, 1953; Dasmann and Taber, 1956b). In general the deer were found to occupy restricted home ranges throughout the year, so that the study area population could be considered as influenced almost entirely by local habitat conditions.

Some dispersal of young deer took place, mostly during late winter and spring, before fawning season. The age class normally involved was the yearling, approaching two years of age. At this time some yearling does drift off to produce fawns of their own; whereas yearling bucks often leave family groups during the winter to take up association with other adult males. Dispersal leads to a limited amount of interchange between populations, with a probable tendency for movement from densely populated to understocked areas.

There may also be some permanent movement of older deer from one population to another, but this was found to be of rare occurrence. Temporary movements of bucks from one population to another during the rutting season normally take place. This leads to a small-scale genetic interchange between populations.

In Table 1 and Figure 1 the detail of population changes in the study area are presented. The discussion which follows pertains to these data.

SEQUENCE OF CHANGES IN THE SHRUBLAND DEER POPULATION

In 1949, before the study area burned, the population density was estimated at about 80 deer per square mile. Approximately this density was also found in areas of shrubland adjoining the study area, so that it may be considered representative of deer populations on stabilized shrubland areas, that is areas not recently burned, but containing a brush-grass interspersion from earlier management.

In spring, 1950, following the fire, the sprouting brush and herbaceous forage attracted many deer—probably those formerly resident there, and those which would encounter the burn in their normal travels. There is also evidence that the area, then understocked with relation to its abundant forage, attracted dispersing yearlings from other areas. All of these deer must have entered the fawning season of 1950 in good condition, for they produced an abundant fawn crop with a subsequent high survival. It is estimated that the population increased to over 100 deer per square mile in summer, 1950, with a subsequent decline to about 88 in May, 1951. The exact figures for

TABLE 1. CHANGES IN THE DEER POPULATION OF THE SHRUBLAND AREA OVER A FIVE YEAR PRIOD

Sex and Age	1951 May est.	June est.	1951-52 Losses	1952 May	June	1952-53 Losses	1953 May
	Deer per 400 acres						
Mature bucks (3 yrs. and older)		6	—3	3	5	—1	4
	6						
Two-year-old bucks		9	—7	2	6	—2	4
Yearling bucks	9	7	—1	6	2	0	2
Adult does (2 yrs. and older)		23	—7	16	23	—1	22
	23						
Yearling does		10	—3	7	7	—4	3
Fawns	17	35	—26	9	29	—20	9
Total	55	90	—47	43	72	—28	44
Percentage loss			52			39	

	1953 June	1953-54 Losses	1954 May	June	1954-55 Losses	May	June
Mature bucks (3 yrs. and older)	8	—3	5	5	—1	4	6
Two-year-old bucks	2	—2	0	4	—2	2	4
Yearling bucks	4	0	4	4	0	4	5
Adult does (2 yrs. and older)	25	—11	14	16	—3	13	14
Yearling does	5	—3	2	4	—3	1	5
Fawns	24	—16	8	20	—10	10	17
Total	68	—35	33	53	—19	34	51
Percentage loss		52			36		

Note: Deer are classed as fawns until 12 months old in May, they then appear in the yearling column in June; similarly they are classed as yearlings until 24 months of age in May, appearing then as two-year-olds in June.

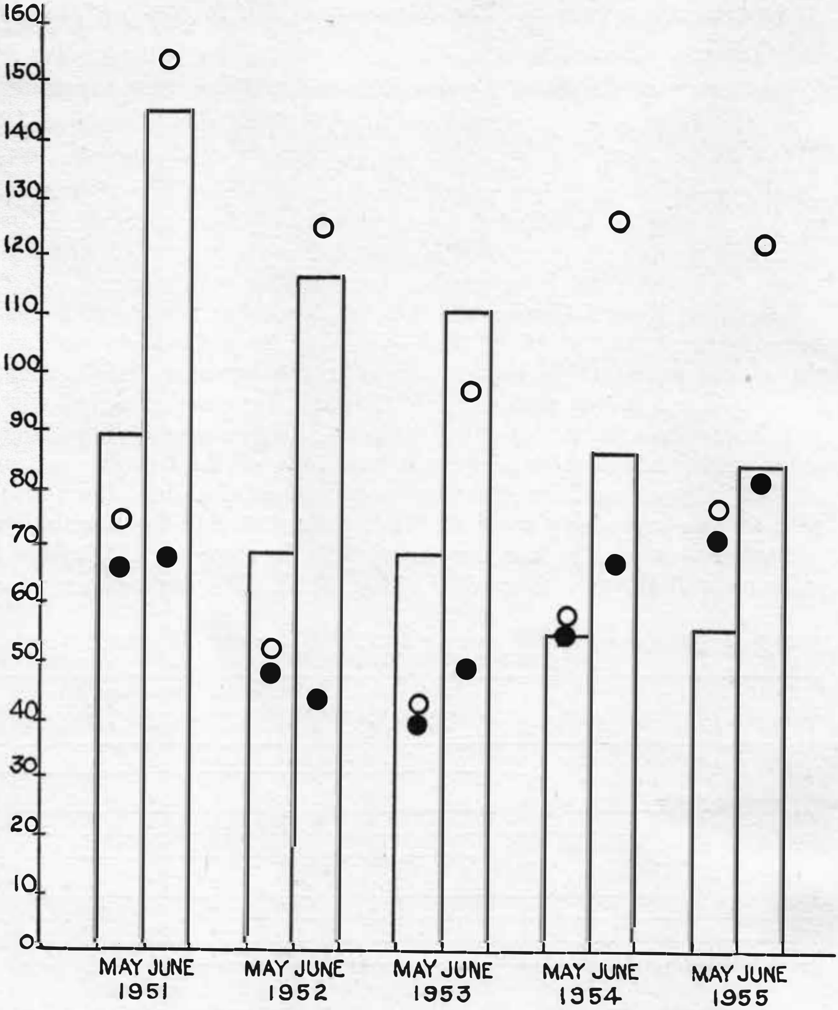

Figure 1. Deer population changes in shrubland. (Bars represent population density in deer per square mile. Open circles represent fawns per 100 adult does; solid circles, bucks per 100 does.)

this period are uncertain, being interpolated from pellet counts in summer, 1949; a few, partial herd-composition counts; and the population structure in summer, 1951.

Intensive studies were begun in July, 1951. From the deer counted, and fresh carcasses present, the May and June populations were estimated. The maximum density of 144 deer per square mile was reached in June, 1951. This large population, however, now inhabited an area which was beginning to decline in forage quality. Sprouts of the brush plants, then approaching two years of age, were losing their nutritive quality (Taber 1956). The deer exerted heavy browsing pressure, with the result that many of the more preferred and nutritious browse plants were killed from over-use, and the forage supply on others was largely exhausted early in the season. With hot, dry, summer weather a seasonal decline in the protein quality of the forage ensued (Taber, 1956), so that by Septemebr, 1951, the protein content of staple browse, such as chamise (*Adenostoma fasciculatum*) and live oak (*Quercus wislizenii*), on which the deer were depending, had dropped to a low level.

With declining forage quality mortality began. By fall, so many carcasses had been located that it was obvious that a major die-off was in progress. Most carcasses showed obvious signs of malnutrition. Deer live-trapped in late summer and fall showed a marked decline in weight and condition. Most of the lactating does and the fawns seen in the field were obviously in poor condition.

An early growth of herbaceous forage, and a fair supply of acorns became available to the deer in October. With increased food the mortality declined. Only two deer were found dead in October-November, compared with 20 in August-September. By December, however, an unusually cold winter began, with more rain and snow than normal. Mortality increased from December to March. In March, sprout growth began on shrubs, herbaceous yield increased, and with this mortality ceased. No deer were found dead in April or May.

The total mortality in 1951-52 amounted to 75 deer per square mile, with malnutrition the major cause of loss. Fawns were most affected, with older does next. Adult bucks, perhaps because of heavy hunting season losses, were less affected by malnutrition. Yearlings did not experience much mortality. In five years of study only one yearling carcass was found in the shrubland area. It is therefore believed that nearly all of the apparent yearling loss represents dispersal rather than mortality.

In 1952, shrub growth was better than in 1951. The reduced deer population exerted less pressure on the preferred forage plants. Through summer and fall little evidence of mortality was found. By January, only 10 deer were found dead compared to 38 in the same period of the preceding year. Nevertheless, the deer were in poor condition. The grass crop was late in 1952, and the deer did not pick up in condition before winter. In late winter and spring, therefore, a die-off is believed to have occurred. In addition to the 10 already found dead, 19 deer were missing by late spring. The greater percentage of these were fawns.

In 1953, the population started at about the same level as 1952. In summer a doe collection was begun which resulted in the removal of 8 adult does, 2 yearling does and 11 fawns. With the addition of hunting season losses of bucks, 24 deer, or 36 per cent of the summer population, were removed as a result of shooting. Following the hunting season, and despite the reduction in population, mortality continued to occur. If probable movement of deer from the population is considered, the mortality was less than in previous years; nevertheless, the population in summer, 1954, reached its lowest point of 53 deer per square mile.

Deer losses in 1954-55 were lower than in preceding years; 19 deer were missing when the populaton was counted in summer, 1955. To check on whether they had died or moved, carcass searches were conducted over part of the area. With this limited searching, nearly half of the carcasses were found. From this evidence, it is believed that most of the adult bucks, does and fawns that were missing had died, whereas the yearlings had probably emigrated.

ANALYSIS OF POPULATION CHANGES

Season of loss. During the study it was obvious that two types of die-off had occurred. One, which took place in 1951-52, began in summer, reached a peak in early fall, declined in late fall, and climbed to a lower peak during winter. The other, occurring in subsequent years, did not begin until winter, and reached a peak during late winter or early spring. The summer-fall die-off was the most severe, and can be considered as abnormal. The winter-spring die-off is probably a normal occurrence in this region.

A possible explanation for these die-offs lies in the protein quality of the browse plants, which is considered in more detail in another paper (Taber, 1956). Protein quality in all chaparral shrubs fluctuates seasonally from a high in spring to a low in late fall. These shrubs can be considered in two categories, based on protein content in the fall: high protein, highly preferred species; and medium to low protein, staple species which provide the bulk of the forage (Bissell and Strong, 1955). In 1951-52 the excessive numbers of deer soon depleted the supply of high-protein browse. By late summer and fall the deer were depending almost entirely on low-protein browse, which was inadequate to maintain their condition. The summer-fall type of die-off may then be related to an early exhaustion of the preferred browse plants, and perhaps also to a depletion of the more nutritious portions of the remaining staple browse plants.

In other years, the summer-fall die-off was probably prevented by a higher average protein intake during summer and fall, resulting from greater availability of the preferred species. In any year, however, with existing population levels, the food quality was not sufficient to bring all of the deer into winter in good condition. Therefore, even with no summer-fall die-off, the more vulnerable age classes of deer will be sufficiently weakened to be unable to withstand the strain brought on by winter weather. With a summer-fall loss, most vulnerable deer die, and winter losses are lighter; otherwise the winter-spring loss is relatively severe.

Cause of loss. In the study area malnutrition unquestionably ranks first as a mortality cause. All other causes of loss were relatively minor.

Predation is carried out by a resident population of bobcats, a few marauding dogs, and a winter influx of a few coyotes. In the period 1951-53 predators took a total of five deer in a total mortality of 75. Seasonally, predation reaches a peak during winter and spring, when fewer small mammals are available.

Accidents, including falling off ledges and drowning, affect fawns primarily. As a mortality factor accidents ranked equal with predation, taking five deer during 1951-53.

Excepting the doe collection, hunting was a minor cause of loss. In 1951 the hunter concentration was heavy, and the kill amounted to nine per cent of the summer population. In 1952 a somewhat lower number of hunters took four per cent of the population. During subsequent years the area attracted few hunters and the kill was lower.

Dispersal removes a small percentage of the total population each year. We believe that 10 yearling does, 1 yearling buck, 2 or 3 adult bucks, and perhaps 1 or 2 adult does moved out of the area in four years. For yearling does, 38 per cent of the average summer population dispersed from the area. For other sex and age classes the percentage affected was low (one to seven per cent). This dispersal includes both actual emigration to new, and perhaps distant areas, and a drift into peripheral areas. This drift may not involve a complete change in home range, but an extension of home range accompanied by a desertion of a previously occupied portion.

The fact that yearling does are most commonly involved in dispersal movements may be significant. It has been previously reported (Dasmann and Taber, 1956b) that there is a degree of territorial behavior among adult does, with crowding leading to an increase in friction and conflict among them. This could discourage does approaching their first fawning period from attempting to settle and raise fawns in an area already thickly populated with older, established adult females.

Natality and fawn survival. The first doe collection, in 1949-50, was from stabilized shrubland on and around the study area. It indicated a natality of 146 fawns per 100 adult does. The subsequent collection, from the study area, in 1953, also showed a natality of 146 fawns per 100 adult does. By comparison the June fawn count in the later year revealed only 96 fawns per 100 adult does, indicating a heavy early fawn loss.

If we take the two corpora lutea, and embryo, counts as representative, it would appear that the reproductive rate is fairly constant on shrubland areas. The differences in the observed fawn crop from year to year probably reflect the viability of new-born fawns, and their survival during early weeks of life. Thus, in 1952, the does entering the rut were in poor condition, and remained in poor condition through the winter. This resulted in a heavy early fawn loss. In 1950 the deer were presumably in excellent condition, with the result that the 1951 fawn count indicated little early fawn loss.

Looking at the evidence for fawn survival through the year, it appears that the most important factor determining the productivity of the population is neither the fecundity of the females, nor the ability of the fawns to survive the first month of life, but rather their ability to live through the first ten months. From 1951 to 1955 fawn mortality took from 74 to 50 per cent of the fawn crop. This probably further indicates that throughout this period the deer were in close balance with the food supply of the area.

Sex ratios. It will be seen in Figure 1 that the number of bucks per 100 does has fluctuated along with the fawn survival. In this area the sex ratio among adults is partly determined by hunting pressure, but more strongly by fawn survival. It has been previously reported (Taber and Dasmann, 1954) that male fawns have a higher mortality rate than females where food supplies are limited. Following a year with a heavy fawn loss a much greater percentage of females than males reach yearling age. The sex ratio consequently becomes more unbalanced.

Density and carrying capacity. If population density figures for the entire period are examined it will be noted that before the 1949 fire the summer population in stabilized shrubland was about 80 deer per square mile. In 1954-55, five and six years after the fire, the summer population had again leveled off at 80 deer per square mile, or a pre-fawning density of about 50 per square mile. It can perhaps be assumed that this represents the normal carrying capacity of shrubland habitat not subjected to frequent burning. This 1954-55 density is two to three times higher than the density on adjoining areas of dense, unburned chaparral.

The population fluctuations exhibited by deer in chaparral can be termed irruptive. Irruptions take place following a major increase in carrying capacity such as will result from fire. This was evident in the study area in 1950 to 1951. At this time the population was below carrying capacity; fawn survival was excellent, and mortality low. Old deer, that would have died under less favorable circumstances, survived. There was an immigration of yearlings into the area. Die-offs follow when the carrying capacity of the environment is exceeded, the more palatable and nutritious components of the forage are consumed, and the deer are left to subsist on forage of lower quality. Thus, two years after the burn, in 1951, a decline began which continued until 1954. The 1953 doe collection probably only hastened the decline, which would have occurred in any event in its absence. The first year of a die-off, such as 1951-52, tends to be most spectacular because of the accumulation of older deer in the population, and because of the usually high fawn crop produced the year preceding the decline, while food supplies were still adequate. Following the initial die-off the population decline is more slow, until eventually, as in 1954-55, mortality and dispersal each year combine to hold deer numbers near the level that the habitat can support. A balance is thus reached between a relatively stable deer population and a relatively stable forage supply.

SUMMARY

A study was made during a seven-year period, from 1949-1955, of a deer population inhabiting fire-modified chaparral, or shrubland, in Lake County, California.

During the study period the deer population increased greatly following a fire in September, 1949. A peak of population was reached in summer, 1951, after which the population density declined. The decline was most severe in its first year, 1951-52. After that a slower decrease occurred. In 1954-55 it appeared that the population was reaching a levelling-off point, with numbers equal to what had been present before the fire, a summer density of 80 deer per square mile.

In the period of population increase, fawn survival was excellent, old deer survived well, and a dispersal of yearlings into the area took

place. In the period of decline, fawn survival was poor, older deer died, and yearlings, as well as other deer, moved out of the area.

Two types of die-offs occurred. One, a summer-fall die-off in 1951-52, was severe and apparently unusual. The other, occurring in all years, was a winter-spring die-off, apparently the more usual pattern. Both types of die-off can be explained by reference to the protein content of the available forage.

The available evidence indicates that the shrubland habitat will support a relatively stable deer population, with mortality and dispersal keeping it in rough balance with the forage supply. The density of shrubland deer populations, when apparent stability is reached, is two or three times higher than that of deer living in dense, unmodified chaparral.

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DISCUSSION

MODERATOR SEAMANS: I think that we can all appreciate the information which Dr. Taber has given us. I am sure that this must have created some comments.

DR. W. E. SWANK [Arizona]: Did I understand that this was merely a plan under which you created your layer?

DR. TABER: This was a managed area, and we had two kinds of fire in California—fire under control and fire not under control. In the first place, the area was managed with fire under control in order to form this shrubland and then wild, uncontrolled fire swept the area. The results of the uncontrolled fire are the results that I am describing.

DR. SWANK: Then in your area, where you do create and hold the layer, did your population remain at a higher level than it did previous to the burning?

DR. TABER: If this area, instead of being shrubland, had been chaparral, the starting level of population would have been 20 deer to the square mile. The buildup would have been to the same peak, 140 to the square mile, but the decline would have been down to the original level of about 20 deer to the square mile over a period of five or six years. The difference between chaparral and shrubland is basically the carrying capacity.

MR. CRONEMILLER [San Francisco]: As I understand it, the area was operating under the buck law. What was the kill per square mile?

DR. TABER: The legal kill amounts to about two or three bucks to the square mile. In the unmanaged chaparral it would be about one buck to the square mile.

AERIAL CENSUSING OF THE NELCHINA CARIBOU HERD[1]

GORDON W. WATSON AND ROBERT F. SCOTT

U. S. Fish and Wildlife Service, Anchorage, Alaska

One of the most difficult problems facing the big game manager has always been that of determining the numbers of big game animals inhabiting any given range. Many systems have been devised to inventory such populations, but experience has indicated that no one method is ever completely satisfactory, due to the inherent lack of cooperation on the part of the animals and the inevitable weaknesses of any single system. Consequently, two or more methods have usually been employed to determine big game populations.

During recent years, use of the airplane in census work has become increasingly popular, although it has been suggested by Crissey (1948) and Edwards (1954) that aerial census of certain big game animals is not satisfactory since uncontrollable variables are too common to permit accurate results.

In Alaska, with its lack of roads, difficult terrain, and large area, aerial censusing has been, and continues to be one of the most feasible, if not the only method of appraising population trends in big game herds and other wildlife. During 1955, for example, flight time actually spent in game census and herd composition counts totaled 875 hours, the equivalent of over 93,000 lineal miles of flight. In these surveys of muskox, bison, deer, bear, moose, caribou, sheep and goats, the total of areas completely covered almost equals the size of Louisiana. This would be equivalent to covering a strip more than 16 miles wide from New York to San Francisco. Obviously, the problems of aerial censusing are of unique importance to game management in Alaska. It is the purpose of this paper to discuss some of these problems in the light of recent experience with one big game population.

THE NELCHINA CARIBOU HERD

The most intensive aerial census effort in Alaska has been focused on the Nelchina caribou herd, whose range is located in the south

[1] From joint studies of Federal Aid in Wildlife Restoration Project 3-R, Alaska, and the Office of River Basin Studies, U. S. Fish and Wildlife Service.

central portion of the Territory, about 125 miles northeast of Anchorage (Figure 1). This herd has been resident within an area of about 10,000 square miles for the past 15 to 25 years, without making long seasonal migrations through passes in nearby mountain ranges as was formerly the case. Its present range is easily accessible from the large cities of Anchorage and Fairbanks, and the continuing availability of these caribou to ever-increasing hunting pressure makes it one of the most important big game herds in the Territory (Anon., 1954).

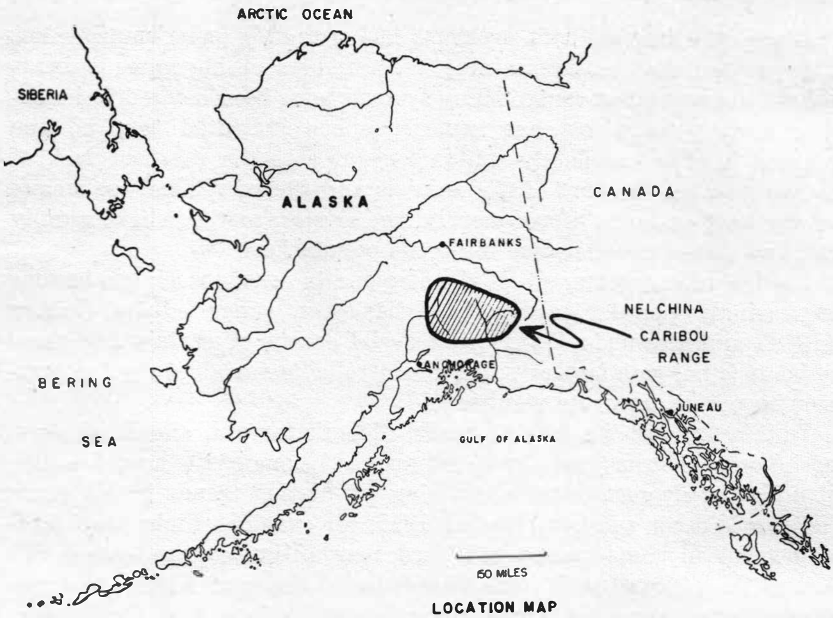

Figure 1. Location map of Nelchina caribou range.

Since systematic observations were begun seven or eight years ago, the Nelchina herd has consistently wintered in the central and southeastern portions of its range. This region is characterized by open to dense stands of spruce, birch, and aspen, interspersed with muskeg, many open meadows, and lakes (Figure 2). During the months of January and February, when censusing usually takes place, the temperature ranges from 30° F. to as low as —50° F. Snowfall averages about 40 inches per year throughout this lowland area, with an average late winter accumulation of about 30 inches on the ground.

Figure 2. View showing typical terrain and cover of Nelchina caribou winter range.

CENSUSING, 1948—1954

Prior to 1948, population estimates were obtained from the reports of wildlife agents, trappers and other outdoorsmen. The most recent estimate before the inception of aerial censusing was about 4,000 animals (Anon., 1947).

The first aerial count was made in November of 1948 by two observers and a pilot in a liaison-type aircraft. An attempt was made to systemize coverage by flying parallel flight lines across the area, but success was questionable due to uneven distribution of the caribou, and the inexperience of the observers with the area and the techniques of aerial observation. A total of 4,019 caribou was recorded and the herd estimated at 4,500 to 5,000 animals. In 1950, under similar circumstances, 4,447 animals were counted and the total herd was estimated at 5,000 to 5,500 animals. The 1952 count revealed 6,973 animals, with no population estimate being made. The 1953 estimate was about 7,600 caribou, based on 6,263 animals actually tallied. Table 1 summarizes these and subsequent census results.

TABLE 1. SUMMARY OF CENSUS RESULTS AND ESTIMATES OF POPULATION SIZE IN THE NELCHINA CARIBOU HERD—1948-1955

Year	Census Count	Population Estimate
1948	4,019	4,500-5,000
1950	4,447	5,000-5,500
1952	6,973	No estimate
1953	6,263	7,600
1954	9,923	13,200
1955	18,654	37,000-45,000

The first four attempts at aerial census added materially to basic knowledge of the Nelchina caribou herd, but all suffered from unavoidable weaknesses of design and execution. Patterns of movements and distribution of the caribou were still imperfectly known, and personnel turnover prevented continuity with experienced pilots and observers. The limitations of time, money and equipment precluded the intensive coverage that would have been desirable, and these early counts should more properly be considered as "surveys" rather than truly adequate samples. One of the misconceptions associated with the early counts was that statistically valid principles of representative sampling could not be applied to a population as capricious as caribou.

The census of January 1954, embodied several improvements over previous efforts. Two airplanes were used, manned by individuals with considerable knowledge of the area and the habits of the animals, and who had, through previous years' experience, gained familiarity with aerial observation techniques. A general reconnaissance was made prior to the count to delimit the portions of the range in which the caribou were wintering. This area was then divided into eleven sectors which were covered by transects from one to five miles apart, with transect widths determined by the maximum distance at which caribou could be seen. After each area was flown, an estimate of the total population within that area was made, based on relative "caribou visibility" as determined by light, ground cover and other appropriate factors in each sector. A total of 9,923 animals was recorded and the total population was estimated at 13,200 animals.

CENSUS OF 1955

Methods. Aerial censusing achieved its maximum intensity and most rigorous quantitative emphasis in February of 1955, when five airplanes and thirteen men were engaged in the census simultaneously. The equipment used included four small 4-place planes with the pilot's seat located in the left-front position, and one two-place aircraft with the pilot located in the front seat.

A preliminary survey was made in a long-range, twin-engine aircraft to determine general location and distribution pattern of the caribou. On January 31, the five small aircraft entered the area along separate routes in order to delimit the distribution pattern in greater detail.

From observations made during the fly-in, it was determined that distribution of the animals was relatively homogeneous over a well-defined portion of the range, and that they were generally arranged in small groups. Such a situation is ideal for sampling purposes, and it was decided to try for both a representative sample and a high sampling intensity—the latter being possible only by virtue of the unprecedented concentration of personnel and equipment. A sample was designed using one-half-mile wide transects distributed in a parallel grid pattern at one mile intervals. This would result in approximately 50 per cent coverage of the area, and, theoretically, of the animals present. As the census progressed, it was decided to reduce the sampling intensity on a small section in the southwest portion of the range because of the small number of caribou present. This resulted in a 22 per cent coverage of that area.

Before starting the census, participants were given an opportunity to "calibrate" their angle of sight from the air by reference to a measured quarter-mile distance on the ground. They were also given a familiarization test consisting of a series of actual photographs of various-sized groups of caribou as seen from the air. This provided an opportunity to gain proficiency in estimating numbers of caribou in groups, and it also was a revealing measure of this ability in the average observer. Forms were provided for recording census data in the field, and all observers were asked to plot in detail on maps, areas unoccupied by caribou, those containing a high density of animals, and other data such as direction of movements. Observers were also asked to record, at the end of each transect, their estimate of the proportion of animals they overlooked on that transect. It was recognized that seldom, if ever, do aerial observers see all the animals they are attempting to count; and it was felt that no one would be in a better position to evaluate this source of error than the man doing the actual counting. He alone knows how much his attention has been distracted, or how light, ground cover, or other factors have affected his vision.

The portion of the range occupied by caribou totaled about 3,111 square miles, and this was covered by 74 transects averaging 34 miles in length. The area was divided into several sectors, each of which could be covered in one day of flying by one crew. The actual censusing took 43.5 hours of flying time and was conducted on February 1 and 2. Certain isolated small bands of caribou outside the census area were given total counts on February 3, 1955.

Results. On the area that received 50 per cent coverage, 17,965 caribou were actualy tallied; while on the area of 22 per cent coverage, 151 animals were counted, for a total within the transect strips of 18,116 animals. An additional 538 animals were recorded in isolated bands, bringing the actual number of counted animals up to 18,654. Expanding these figures directly according to per cent coverage, the minimum population was established at 37,156 caribou.

Initial care in the design of the sample made it possible to calculate total population and also evaluate reliability in another manner. More exact boundaries of the total area actually occupied by caribou, as well as sub-divisions of high and low density, were plotted from the field records. These areas were then planimetered, and the data treated as a stratified random sample. A weighted mean of 15.5 caribou per square mile was computed for the modified total of about 2,538 square miles actually occupied at the time of the census. These figures yielded a total of 39,466 caribou for the entire population. Stratification on the basis of density reduced the effects of variability between transects, and calculated confidence limits at the .95 level indicated a sampling error of only about four per cent of the population estimate. This method of computation was chiefly valuable as a means of assessing variability and as a cross-check of the results obtained by direct expansion of the per cent coverage figures. The population estimate obtained in this way was subject to additional errors resulting from its dependence on square-mile area calculations.

The two figures of about 37,000 and 39,000 caribou, cited above, were in close enough agreement to be accepted as minimum population estimates. A maximum estimate was obtained by correcting each transect total through addition of the estimated proportion of caribou missed on that transect. The cumulative effect of these corrections amounted to an increase of about 22 per cent over the actual tally on the transect strips. Applying this correction to the direct expansion figures resulted in a maximum estimate of over 44,000 total caribou in the Nelchina herd.

DISCUSSION

A caribou population estimated at about 13,000 animals in 1954 obviously could not triple in size to about 40,000 in one year, therefore, the 1955 census results make it necessary to account for the disparity in some other way. There are four alternatives to consider:

1. The 1955 census was in error.

2. Natural increases had, in fact, produced a population of about 40,00 from one of about 5,000 in 1948.
3. The major increase was due to recruitment from other caribou herds.
4. Earlier censuses and resultant population estimates were in error.

Covering these points in order, the intensive effort devoted to the 1955 census made it certain to be more accurate and reliable than any of the previous counts.

The natural increase required to produce the 1955 population from the one estimated in 1948 would amount to over 40 per cent annually during this period. While sustained increases of this magnitude may be possible with deer, they do not seem likely with caribou. It has been shown (Scott, 1954) that growth in the Pribilof reindeer population, reported by Scheffer (1951), averaged only 26 per cent annually during the "eruptive" period. Furthermore, the greatest winter calf proportion recorded in the Nelchina herd during the period in question was only 24 per cent. Natural increase alone is obviously not responsible.

The Nelchina range is surrounded on all sides by well-traveled highways or the Alaska Railroad, as well as mountain ranges. It is extremely unlikely that any significant number of caribou could enter the area without detection. The nearest other large caribou herd is almost 200 miles away.

The only remaining explanation is that the census counts and resultant estimates from 1948 to 1954 were in error. When plotted graphically, the population estimates for this period show a relatively steady trend upward, amounting to about 20 per cent per year. Although the estimates themselves were undoubtedly incorrect, the rate of growth indicated may actually have occurred. Were this the case, extrapolating backward in time from the 1955 estimate would indicate that a population of about 10,000 must have existed in 1948, and that the original census, therefore, accounted for only about one-half of the animals present.

SOURCES OF ERROR

The results of the 1955 census were startling in comparison with those of previous years, and they served to emphasize the ease with which certain common errors can cause bias of aerial census results. The nature of some of these errors has become better understood through analyzing the data from the 1955 census of the Nelchina caribou herd and re-appraising the earlier censuses in the light of the 1955 findings. These errors are discussed below.

Sampling errors. Rarely can total counts be made of any sizeable big game population. A census usually, therefore, becomes a sampling attempt, which must conform to the statistical laws of sampling in order to be successful. Population estimates can be made on the basis of almost any kind of survey, but only by proper sampling design can the reliability of results be evaluated. It must be clearly determined exactly what population is being sampled, and equally clearly understood just what inferences can safely be drawn from the sample results.

The intensity of sampling in the 1955 caribou census was much greater than in most sampling efforts and this alone eliminated many of the difficulties associated with earlier attempts. Future censuses will probably be successful at lesser intensities.

The caribou were sampled at a time when their distribution was most homogeneous, thus reducing variability in the sample to a minimum. Previous counts were complicated by uneven distribution and irregular occurrence of concentrations of caribou. Scheduling a census seasonally to take advantage of homogeneous distribution can be an important consideration.

With adequate planning, data can also be obtained during the actual conduct of the census which will permit later stratification of the sample for better evaluation of results and reduction of the effects of variability.

Errors of observation. Although it has long been recognized that aerial observers do not see all animals within a transect strip (Buechner *et al.*, 1951; Crissey, *op. cit.*), there is strong tendency to minimize this factor, especially among inexperienced observers. The animals that are seen usually appear so obvious from the air that the observer tends to feel that he is seeing them all.

This factor was stressed in the 1955 caribou census, and participants estimated that a mean of 22 per cent of the animals were missed on transects. This figure agrees closely with those reported by Sumner (1948) and Edwards (*op. cit.*) who found that aerial counts were about 20 per cent less than ground counts. Banfield *et al.* (1954) reported similar findings.

Positions of the observers in an aircraft also affect their efficiency. During the 1955 census, neither pilots nor rear seat observers tallied as many caribou as did front seat observers. Pilots averaged 25 per cent, and rear seat observers 9 per cent less than the front seat count. Pilots and rear seat observers also estimated missing an average of

26 per cent of the animals on transects as compared to 18 per cent for front seat observers. Under-counting by the pilot is readily understood since his attention is divided in maintaining the proper course as well as counting animals. The difference between front seat and rear seat observations has been attributed to eye-fatigue by Edwards (1954), but it is believed that such difference is largely due to relative fields of vision. The front seat man is able to see animals ahead of the aircraft and may follow them as they pass behind the plane, while the man in the rear seat has much more limited vision.

Experience in aerial observation also has a very real effect upon a man's ability to count animals from the air. Until an observer has learned to recognize the strange shapes and shadows of animals in various positions on the ground, he is likely to overlook a large proportion of those he is seeking to count. It has frequently been noted than an experienced pilot, even though his attention is divided, will consistently see animals that an inexperienced observer overlooks.

Errors of enumeration. There is little difficulty in counting animals individually or in small groups, but larger groups are a problem to the observer in a fast-moving aircraft. Participants in the 1955 census had an opportunity both to test and improve their ability to estimate numbers by reference to the series of caribou photographs. It was found that when caribou appeared in groups of less than 100, observers consistently under-estimated by an average of 6 per cent, while in viewing groups of over 1,000 the tendency was to under-estimate by 14 per cent. On several occasions in recent years, actual field estimates of large groups of caribou have been checked against aerial photographs taken at the time. In each case, there was a defiinte tendency to under-estimate the numbers of animals in the large groups, and the larger the group, the greater was the under-estimate. Observers must be carefully trained to overcome this natural tendency.

Mechanical errors. No matter how well designed a census may be, the mechanics of execution—following the plotted transect line, maintaining proper transect width, and the like—are always a problem.

A combination of accurate, large scale maps, and numerous recognizable terrain features such as characterize the Nelchina range, make transect location relatively easy in flight. Although some wandering may occur, with resultant slight lengthening of transects, other associated errors tend to be compensatory.

The possibility of including or excluding animals at the perimeter of the transect has been the subject of much discussion by Edwards (1952) and Banfield (*op. cit.*). Slope of the ground, elevation, relative angle of the wings on which the line of sight and resultant perimeter of the transect is based, altitude of the aircraft, and the observer's ability to judge distance are some of the possible sources of error.

Those concerned with aerial surveys of waterfowl on the northern breeding grounds have been attempting to overcome these errors for several years, and it is to be hoped that a satisfactory solution will be found before long. In the meantime, it must be admitted that aerial census work involves a lack of precision in several respects, and that the major requirement is to recognize the existence, direction and probable magnitude of those errors that are unavoidable.

Personal bias. A well-designed sample eliminates personal bias, and this was the case with the 1955 census. The 1954 census results nearly doubled the estimate for 1953, however, and it was difficult for many people to accept such a radical departure from previously accepted figures. The extent to which such personal bias may have influenced previous population estimates is uncertain, but it may well have been an important consideration. Pre-conceived ideas are often difficult to overcome, but they obviously must be dispensed with when dealing with anything as unpredictable as a caribou population.

SUMMARY AND CONCLUSIONS

1. An aerial census of the Nelchina caribou herd was conducted nearly every winter, from 1948 to 1955. The first census resulted in an estimate of about 5,000 caribou. Subsequent estimates showed a continuing slow increase in numbers until 1954, when results indicated almost twice as many caribou were present as had been estimated the previous year. An intensive census was conducted in 1955, utilizing five airplanes and thirteen men. Results indicated the caribou population numbered about 40,000, over three times as many as were estimated in 1954.

2. The 1955 census was designed as an intensive representative sample, with 50 per cent coverage being given to most of a 3,000 square mile area. Analysis of results indicated a high degree of reliability for the population estimate. In the light of the 1955 results, previous censuses were acknowledged to be in error. Indications were that the 1948 census accounted for only about one-half the animals probably present at the time.

3. Failure to adhere to an adequate sampling design is believed largely responsible for errors in the early census results, but this was complicated by errors of observation and enumeration, as well as other characteristic difficulties associated with aerial census of a big game population.

4. The 1955 results demonstrated that when careful thought, good planning, and adequate effort is devoted to the task, an aerial census can yield valuable information—often unobtainable in any other way. The 1955 census also served to emphasize that inadequate efforts, though they may be the "best that can be done" at the time, may provide very misleading answers to the problem of estimating the size of a big game population.

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DISCUSSION

DR. ANTON DE VOS [Ontario]: I would like to get some more information about the methods that you used to get the computation of your half mile. I know that there is a change of altitude and also that your person observing may have some blind spots.

MR. WATSON: Before we started our census we measured off a quarter of a mile area from a known distance on a road. It happened to be the runway of the field that we were using. We were right over the road and we looked over it to determine a quarter of a mile. We did that back and forth several times in each direction and at different altitudes so that the observer himself had a chance to determine the quarter of a mile. We also used strips of tape on the wing or strut of the aircraft for his eye-level measurement. In addition, the large scale maps we were using also had well-defined landmarks and through these we were able to limit ourselves to a quarter of a mile. Of course, the blind spots under the plane we consider to be negligible, although they do exist. We have as yet made no effort to use tracks as an indication of population other than to signify that there are a lot of animals around.

DR. G. PETRIDES [Michigan]: Did you say that the animals from this herd were non-migratory and, also, what did you figure was the population level?

MR. WATSON: Our population in this area is a non-migratory herd. Their range is 10,000 square miles in extent and the winter range is about 3,000 square miles of that range and there were fifteen and a half animals per square mile during the period of the census.

DR. PETRIDES: Have you any information on the condition of the range and whether there was apparently a carrying capacity beneath or above the present stocking?

MR. WATSON: Well, I am going to hedge on that question by saying that we are presently making clip studies and putting up an enclosure to determine carrying capacity of the range. We think that right now we may be exceeding the capacity. Of course, it is difficult with these animals for they do not stay on a given portion of the range.

MR. STEVENS [Northwest Territories]: We have had the same problems of aerial census that you have had and one thing that I did not get from the paper was some description of cover in that area. Presumably your animals in the winter will be under some sort of cover. Have you had any experience with that?

MR. WATSON: We have had some negative experience. Our method of appraising the number of animals we don't see was for the observer at every transect line to estimate the population or percentage he figured was not seen—depending on the light conditions, cover conditions or other conditions he may have had. We recognize that this is not the best way of doing it and that it is open to a lot of error. These people estimated that they missed 22 per cent of the population.

MR. STEVENS: I would like to say that what we have done is to use one aircraft following the other and then grade the findings.

MR. WATSON: We did that same thing in connection with the 1955 census, where we strung five planes about a mile or two apart and the last man ran into a herd of about 200 more than any of the previous people did. Perhaps the aircraft cause the animals to mill around more on the ground and you see more in that way.

SUMMER STUDIES OF MOOSE IN ONTARIO

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As relatively little information is available regarding the summer movements of moose, their aquatic food habits and other aspects of their behavior, a study was started in July 1952, and continued during the summers of 1953 and 1955[1] to investigate these matters.

This report covers only part of the information obtained; data on behavior, such as vocal and social behavior, diurnal activity, the influence of weather factors upon moose, and aquatic food habits will be discussed in another publication. The present paper restricts itself to observed moose movements, sex and age ratios, antler development and shedding of winter hair.

As moose preferably should be observed as much as possible under undisturbed conditions, an area was selected in the center of the Chapleau Crown Game Preserve. This is the largest wildlife refuge in Ontario, situated in the central section of the province, east of

[1] This study was a field project of the Fish and Wildlife Division of the Department of Lands and Forests, Ontario.

Lake Superior. Studies were restricted to Little Missinaibi Lake, which is ideal for a moose study, because it has numerous arms, enabling one to make extensive trips by canoe, and because it is generally shallow, providing ample aquatic vegetation. This area is practically never visited by human beings. The presence of a fairly recent burn near the southeastern section of the lake provides extensive feeding grounds for moose. The local population has been at or above carrying capacity level for some years.

METHODS USED

A base camp, located on the easternmost arm of the lake, was used as the center of operations. From there daily trips were made along various arms of the lake. During 1952 most of the canoe traveling was done by paddling. However, as it was noticed during that summer that the use of a two and one-half horse-power engine did not unduly alarm moose, considerable traveling was done subsequently by that means. Whenever moose were observed, the engine was stopped and data were recorded on the time and location of observation, and the age and sex of the moose. During 1952 and 1953, binoculars of 6 x 30 and 7 x 50 power, and in 1955 a telescope with a 25x ocular and 6 x 30 binoculars were used. It was endeavored not to approach moose within the flushing distance, because alarming them may result in abnormal movements during successive days. Special peculiarities of individuals were noted in a field book, and when necessary, drawings of antlers or other parts of the body were made. Data were also gathered on the behavior of moose, their aquatic food habits, and weather factors.

In order to avoid disturbance of the local population as much as possible, no one arm of the lake, except the one on which the base camp is situated, was visited more frequently than once every third day. Apart from the base camp, several tent-camps were used at sites suitable for observation, and overnight trips were made to such camps. Normally the canoe was manned by two, but sometimes by three observers.

Daily records were kept about the time actually spent traveling, the time of departure and arrival, and the area covered.

In order to avoid bias in observations, each section of the lake was visited at various times of the day.

Observations were made during the following periods:
July 2—21, and August 2—5, 1952,
May 18—June 18, August 1—31, 1953,
June 3—August 31, 1955.

Although the field work was under supervision of the author, he was able to spend only part of each summer in the study area. Most of the field work was done by students, who were often assisted by field personnel of the Department of Lands and Forests.

MARKING EXPERIMENTS

During the study period efforts were made to mark a number of individuals with various colors of paint in order to follow their movements through repeat observations, and also to establish some index to populations present.

During the summer, moose travel definite trails regularly to and from feeding areas situated in shallow bays of the lake. Along these runways, paint traps were set up. A trap is of a rather simple construction: It is set up between two trees which are located on either side and close to the trail. A piece of cord is then strung across the trail, and attached to both trees at a height of about five feet, so that moose of various ages, excluding young calves, trip the trap, but not deer,[2] or wolves. The string or trip-cord is tripped when a moose travels along the trail and a plastic bag filled with paint is slashed, spilling the paint on the moose.

Although the paint traps generally operate efficiently, results have been discouraging because of the following reasons:

(1) The paint seems to wear off the moose. The blot of paint produced will mat the hair and this hair may fall out. At any rate this is what happened when the paint was tested on domestic cows. A fast-drying enamel paint was used.

(2) Bears, especially when relatively abundant, tamper a great deal with the traps. They usually pull the trip-cord, spilling the paint.

Only one painted moose was ever observed, but this was shortly after it had left a paint trap.

Evidence of successful marking of moose could usually be obtained by checking for paint, along the trail, which had dripped off the animal. In 1952, during a period of about three weeks using four traps, a total of six moose were painted. In 1953 six traps were tripped a total of 27 times during a period of approximately six weeks. In at least eight instances bears had tampered with traps. In 1955 bears disrupted the paint sets so frequently that marking efforts were discontinued.

REPEAT OBSERVATIONS AND MOVEMENTS

Efforts to study the summer movements of moose were stimulated by a series of observations of an antlered cow and her calf in 1951.

[2] No evidence of the presence of white-tailed deer could be obtained.

Antlered female moose are apparently observed only rarely, the only reference about one that has come to my attention is in Seton (1927). The antlers were short and poorly developed for the time of the year. The left antler was protruding upward, and the right one sideward.

Observations of these animals were made along the shores of Schewabik Lake and the Chapleau River along the boundary of the Chapleau Crown Game Preserve during the period August 15 to August 21. We traveled up and down streams at least once a day. The cow was observed with her calf on three days. The cow was observed once more by a trapper on October 31.

Table 1 lists in a chronological sequence the various observations of the two moose. The calf seen on August 15 and 20 is considered to be the same as the one observed in the intermediate period because of its large size and because no other calf was seen previously.

TABLE 1. OBSERVATIONS OF AN ANTLERED COW AND HER CALF IN 1951

Date	Time	Observations		
Aug.				
15	1:30 p.m.	Large calf walking in northerly direction. First calf seen in area.		(Fig. 1,1)
16	9:00 a.m.	Antlered cow and calf.	Calf thought to be same as observed on previous day.	(Fig. 1,2)
	4:00 p.m.	Antlered cow and calf.	About 200 yds. north of morning observation.	(Fig. 1,3)
	5:00 p.m.	Antlered cow and calf.	Not present at last site of observation.	
17	9:25 a.m.	Antlered cow and calf.	Observed north of previous observation. Both disappeared in a northerly direction.	(Fig. 1,4)
	1:15-6:40 p.m.	Antlered cow and calf.	Were not to be seen.	
	6:40 p.m.	Antlered cow and calf.	Noticed on opposite side of lake.	(Fig. 1,5)
	7:30-8:30 p.m.	Antlered cow and calf.	Observed again, little movement.	(Fig. 1,6)
18	10:10-10:25 a.m.	Antlered cow and calf.	Observed south of site of previous day.	(Fig. 1,7)
	4:00-4:45 p.m.	Antlered cow and calf.	Were not to be seen.	
	7:30-8:00 p.m.	Antlered cow and calf.	Observed further south.	(Fig. 1,8-9)
19	6:45-7:10 a.m.	No observations of these moose. Tracks followed.		
	8:45 10:00 a.m.	No observations of these moose. Tracks followed.		
	7:20-7:45 p.m.	No observations of these moose. Tracks followed.		
20	10:30 a.m.	Calf only noticed walking in southerly direction.		(Fig. 1,10)
Oct.				
31	?	Antlered cow noticed by trapper.		(Fig. 1,11)

Figure 1 shows the various sites of observation, as well as the route traveled between these points, based on tracks observed. These data indicate an average movement of 0.4 miles per day.

As no apparent success was obtained with the marking techniques, we were forced to make the best use of such recognition marks as size and shape of antlers, the shedding pattern of winter hair, the shape of the bell and the age of the moose observed. Often a combination

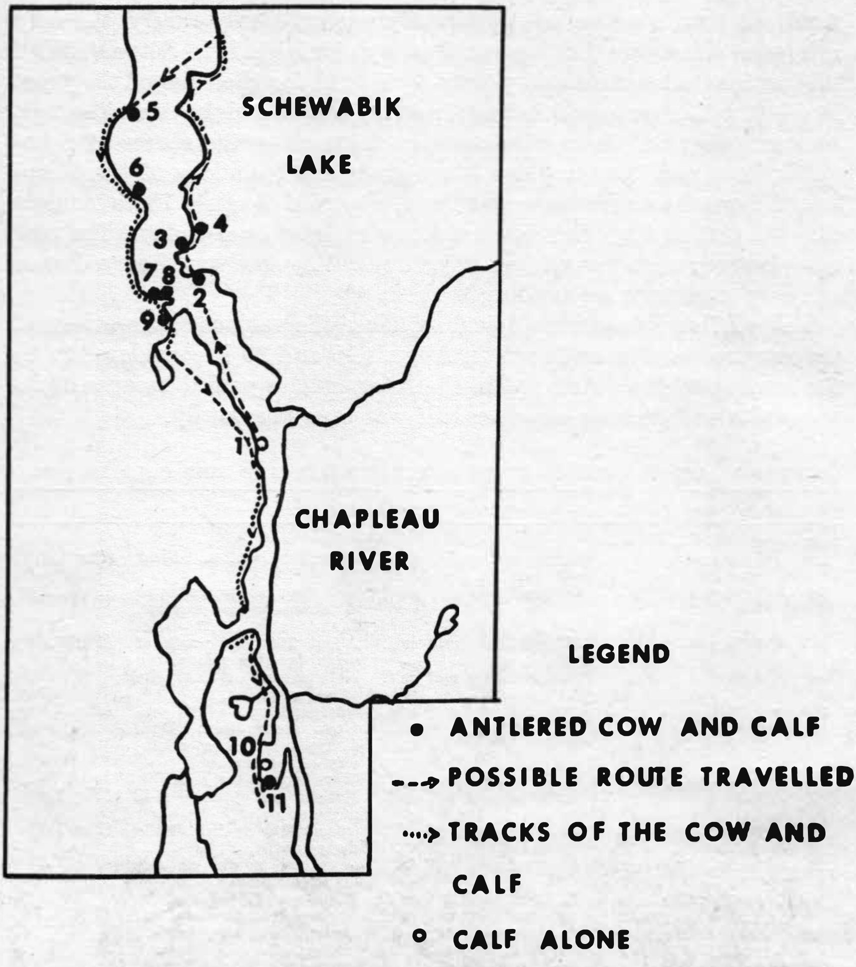

Figure 1. Observations of an antlered cow and her calf during the period August 15 to October 31, 1951. Scale 1 inch = 1⅓ miles.

of two or three criteria made it possible to recognize individuals with a fair degree of certainty. We acknowledge that there is a certain amount of observational bias: the antlers of bulls and the shedding pattern of winter hair change rapidly during late May and June. Similarly, young animals grow rapidly. In 1952 and 1953, when binoculars were used, the chances of mistakes were greater than in 1955 when a telescope with a 25x ocular was used, as well as binoculars.

Only two of the repeat observations were made of definitely known animals. One was a painted individual, and the other was a calf tagged on June 30, 1952. On August 6, 1953 the latter was observed one mile from the location where it was tagged. On August 25 it was again seen about one-quarter mile from the August 6 observation. This information suggests that a moose will remain in the area where it was born. This agrees with a statement made by Skuncke (1949) that a moose family in Sweden remained year after year on a small tract of land.

All other data are concerning repeat observations of moose about whose identity we feel relatively certain.

TABLE 2. RATIO BETWEEN REPEAT OBSERVATIONS AND TOTAL OBSERVATIONS

	1952		1953		1955		Total 3-year period	
	Any Moose	♂♂	Any Moose	♂♂	Any Moose	♂♂	Any Moose	♂♂
Total observations	86	33	91	44	172	51	349	128
Repeat observations	16	10	9	5	25	14	50	29
Percentage of repeat observations	19%	30%	10%	11.5%	14.5%	27.5%	14.3%	22.5%

Undoubtedly more repeat observations were made than could be recognized as such, particularly among the females and yearling bulls. Because of the better recognizable features of bulls, the ratio between repeat observations and total observations can be expected, and was recorded to be, higher in that sex group and may be closer to actual conditions (Table 2). Supposing that the number of repeats for bulls for 1955 is reasonably accurate, and that at least 27.5 per cent of the total number of moose observed were repeats,[3] then an actual population of 125 moose might have been present in the study area in 1955. The possible utilized area of the observed moose was estimated at 80 square miles: The maximum length of the censused part of the lake is eight miles, and the maximum width six miles. As moose undoubtedly move at least one mile inland from any bay, one mile was added either way to compute the approximate summer range. This suggests a density of one to two moose per square mile.

The linear distances moved by individuals which were observed more than once, the time lapse between observations, and the number of observations were recorded (Table 3). Most of the repeat observations of moose during the period 1951-1955 were made at or near the same spot and usually on the same or consecutive days. The high frequency of observations of this nature suggests that moose are often

[3] The 1955 sample is most accurate.

inclined to stay around a suitable feeding place for a length of time. Data also suggest that many animals, after having been at a certain location for some time, will wander off and then return after a lapse of time. The movements of a large bull moose observed on June 21, 22, July 12 (twice), 13, 14, and 15, 1952, on an arm of Little Missinaibi Lake might be more or less characteristic (Figure 2).

TABLE 3. NUMBER OF CASES OF MOVEMENTS OBSERVED OVER VARIOUS DISTANCES[1]

Number of Days After	Movements in miles										
Previous Observation	0	⅛	¼	⅓	½	1	1¼	2	3	4	6½
Same Day	7		2	1							
1	10										
2	1	4	2		2						
3	1										
4	5									1	
5					1		1				
6	1		1								
7	1										
8	1										
9	1										
10						1					
18	1										
19			1								
20					1						1
30									1		
38	2										
45								1			

[1]All movements are recorded as linear distances between observation sites.

The scarcity of repeat observations over distances of more than one-half mile (six out of a total of 46) may suggest that the summer movements of moose are restricted to a rather limited range. However, the longer the time lapse between observations, and the farther the distance moved by individuals, the greater is the chance of observational bias.

Observations made by Mr. V. Crichton of the Department of Lands and Forests are also worth recording. He observed a very large bull moose on June 28, July 2 and 12, and August 1, 1953, in Cochrane township, Chapleau Crown Game Preserve (Figure 2). It could be readily recognized by its large antlers, with 14 points on the one and 12 on the other, and by one point on one antler shaped like a hook. The linear distance which this bull moved was four miles in the period of 33 days.

Moose observations are definitely concentrated in places where aquatics are available in ample supply (Figure 3). Wherever the shore line is steep and rocky and the water deep, moose are not observed unless they are swimming past.

A limitation of the present study is that we do not have adequate

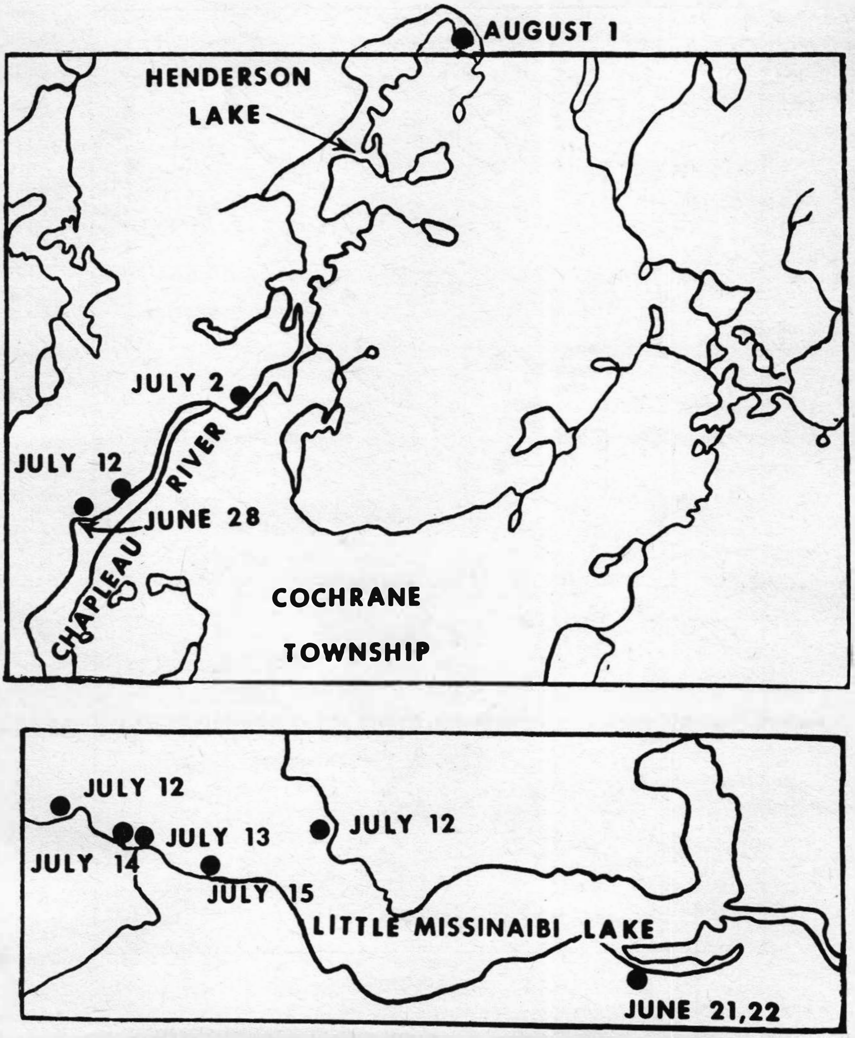

Figure 2. Upper—Movements of a bull moose in Cochrane Township during the period July 2—August 1, 1953. Scale 1 inch = 1 ½ miles. Lower—Movements of a bull moose along an arm of Little Missinaibi Lake during the period June 21—July 15, 1952. Scale 3 inches = 1 mile.

knowledge of the movements of moose in the forest during the summer season. In order to obtain more information about such movements, moose trails were followed as far as they were visible, and mapped. However, these trails generally become invisible about 100 yards from where they enter the water. Several trails lead from one bay with

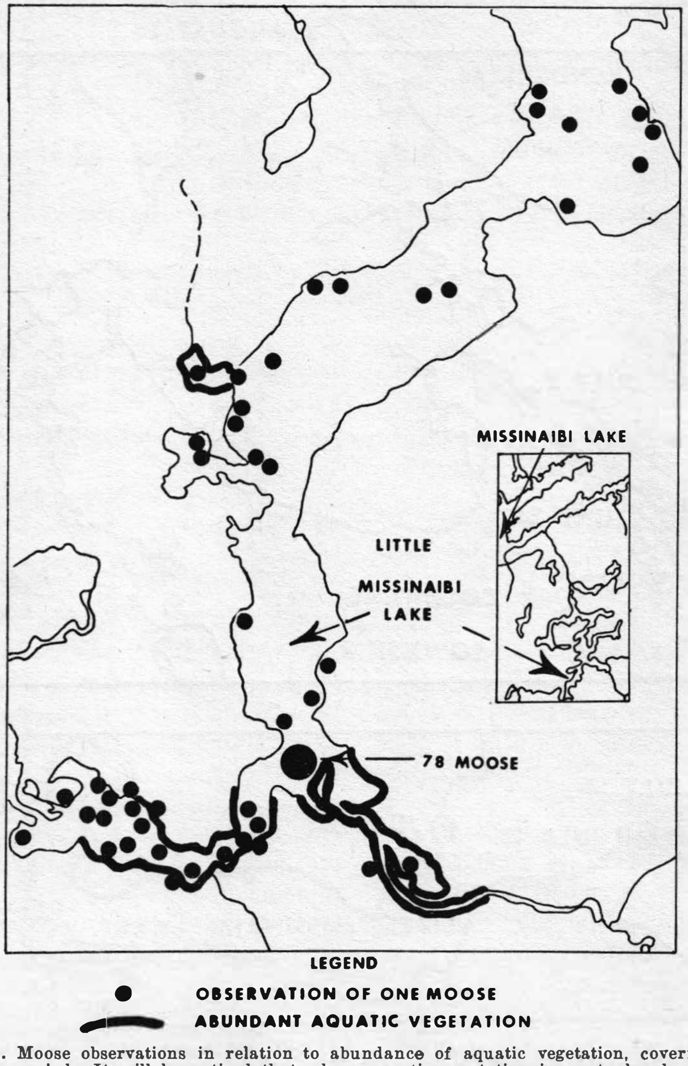

Figure 3. Moose observations in relation to abundance of aquatic vegetation, covering the three-year period. It will be noticed that where aquatic vegetation is most abundant, most moose observations were made. The large circle represents 78 moose in that general location. The insert shows the shape and the location of Little Missinaibi Lake. The arrow points to the section which is enlarged. Scale 2 inches = 1 mile.

ample aquatic vegetation to another and it may be surmised that at least a good percentage of the moose use trails to take short cuts through the forest from one feeding place to the next. At times moose will wander through the forest during the summer, more or less at random, in the search for browse. Movements in the forest may have a different pattern than in an aquatic environment.

SEX AND AGE RATIOS

The sex ratios obtained in the study area in 1952 and 1953 indicated a higher ratio of bulls than in the remainder of the Chapleau District (Table 4). In 1955 this was the reverse. It seems unwise to

TABLE 4. SEX AND AGE RATIOS OF MOOSE OBSERVED[1]

	1952		1953		1955		Totals	
	Study Area	Chapleau District	Study Area	Chapleau District	Study Area	Chapleau District	Study Area	Chapleau District
♂♂ Adult	41	283	44	229	69	212	154	724
♀♀ Adult	18	268	27	176	67	137	112	581
♀♀ plus 1 calf	6	61	2	50	18	62	26	173
♀♀ plus 2 calves	0	28	0	21	0	45	0	94
♂♂ 1 year	4	0	4	0	4	0	12	0
♀♀ 1 year	6	0	9	0	2	0	17	0
Calves	6	117	2	92	18	152	26	361
Adult, sex?	2	0	4	0	0	0	6	0
Yearling, sex?	1	89	0	44	0	61	1	194
Age and sex?	0	0	1	91	8	57	9	148
Ratio Adult ♂♂: Adult ♀♀	69:31	51:49	63:37	57:43	51:49	61:39	58:42	55:45
No. calves per 100 ♀♀	33	44	7	52	27	111	23	62

[1]Moose considered to be two years old were bulked with adults in this compilation, because of the difficulty of recognizing animals of this age group.

try to draw any conclusions from these data, since the sample obtained in the study area is too small for statistical analysis and because data were collected on a different basis in the Game Preserve than in the remainder of the Chapleau District. While in the study area a considerable percentage of the observations were made during early morning and late evening hours, most of the observations in the Chapleau District were made closer to the middle of the day. As other data, not discussed in this paper, indicate a differential activity of bulls and cows during the middle of the day than early in the morning and late in the evening, the two sets of data do not seem sufficiently comparable. Moreover, in the study area data were collected more carefully than in the remainder of the Chaplau District, where various sources of information, including train crews, tourists, *et cetera,* were used. It is also possible that the sex ratios of moose observed in the water are different from actual ratios. Skuncke (1949), for example, states that bulls usually confine themselves to hiding places during the period that the antlers are developing rapidly. All that can be suggested at the present time is that the ratio of bulls (a 58 per cent average for the three periods) is higher than under "average" Ontario conditions (51 per cent for Ontario, 1947-1949. Peterson, 1955).

The number of calves seen throughout the period of observation seems low as compared with data obtained for the remainder of the District (Table 4), especially when it is considered that more careful observations were made. No twin calves were ever observed, although one set of twin yearlings was seen during 1955. The percentage of yearlings observed is also lower than in the Chapleau District sample.

If the observations made represent existing conditions, then it appears that continuous protection in a wildlife refuge (this Preserve has existed since 1925) results in an excess of bulls and poor reproduction, the latter possibly caused by poor range conditions due to overpopulation.

ANTLER DEVELOPMENT

This discussion will be restricted to the development of antlers of large adult bulls. Antlers are shed between late November and late March. Old bulls generally shed their antlers earlier than the young ones and also start antler development earlier. During an aerial survey in the Fort Frances Forest District in 1951 it was noticed that in late February a large percentage of the bulls were still carrying their antlers.

No obvious signs of antler growth can be noticed during the first half of April. During the second half of that month, however, growth becomes noticeable.

According to Skuncke (1949) the period of May to August is the principal antler-forming time in Sweden, which conditions are similar to those of Ontario. During May and June the antlers grow very rapidly (Figure 4). The brow tines develop faster than the palmated portion of the antlers. It was noticed that some bulls show more rapid development than others. During early May knobs are noticeable which later on in the month start to develop into the palmated part of the antlers, or "palms," and the brow tines. By the end of May the palmated part of the antlers is about one-third of its normal length, or about one foot long.

The following sums up in a chronological sequence the development of antlers of individuals selected from field data:

No knobs were noticed along the edge of the palmated portion of the antlers of a bull observed on May 31, 1953. The first definitely pronged brow tines were noticed on June 3, 1955. The same bull had one small knob on the left palm. Two bulls observed on June 4, 1955 had definite knobs on the outer edges of each palm. A bull which was sighted on June 13, 1955, had fairly well-developed brow tines, and three distinct knobs on the palmated portion of the right antler. Another bull observed on June 18, 1955 had well developed brow tines.

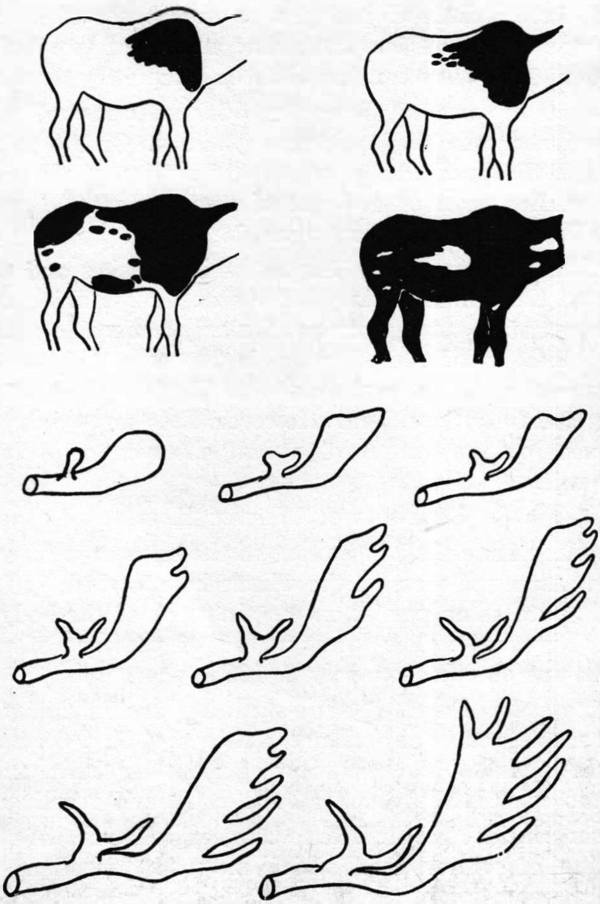

Figure 4. Upper—From upper left to lower right, progressive shedding of winter hair. Summer hair is indicated as black. Lower—Progressive development of an antler between early May and late August.

The brow tines of a bull sighted on July 4, 1953 were practically full-grown and his palms were developed to about two-thirds of their total length. The palmated parts of the antlers of a bull seen on July 12, 1953 were nearly full-grown. During early July several knobs start to form along the edge of the palms of adult bulls. These develop into prongs by the end of July. By early August the palmated portions of the antlers of most bulls have reached full development, and small knobs start to form at their distal portions. The first knobs on the distal parts of palms were observed on August 11, 1953. On

August 17, 1953 well-developed prongs were observed on the distal portion of the antlers of one bull. The antlers of two bulls sighted on August 23, 1953 were considered to be completely developed.

Velvet starts to come off the antlers during August. The first sign of loss of velvet was noticed on August 3, 1953. On August 25, 1953, the velvet had disappeared from the distal portion of the palm of one bull. The earliest sign of removal of some patches of velvet were noticed by Peterson (1955) on August 19, 1947.

During late July and early August white patches and stripes are noticeable on the palmated parts of the antlers. During the second half of August such patches are particularly noticeable on the upper portion of these palms. According to Peterson (1955) the white color is caused by the removal of velvet. This may be the case when the antlers are fully developed. However, I do not think that white bands present on the antlers of a bull observed on July 28 were caused by this.

SHEDDING OF WINTER HAIR

The shedding from the winter coat to the summer pelage begins in early May. Although most of the winter hair is shed by the end of that month, patches do persist on certain parts of the body throughout June (Figure 4). The latest record of presence of patches of winter hair was obtained on July 2, 1955.

The spring coats of moose, before shedding, are light grey-brown in color, and are ragged in appearance. After shedding, the new coat of shorter hair is almost black in most of the older bulls, and reddish brown to tan color in the younger bulls, cows, and yearlings.

There is a considerable difference between individuals in regard to the shedding of winter hair, which may be dependent upon the physiological condition of the animals. Generally adult bulls acquire a complete summer coat faster than cows and yearlings and they seem to start shedding earlier as well.

Table 5 shows the chronology of the shedding of winter hair in moose. It consists of a selected representation of the data obtained. Figure 4 shows the general trend which can be observed in hair shedding in three phases.

The sequence of shedding of the winter pelage seems to be as follows:

It generally starts on the shoulder hump region, proceeds along the back of the neck, down towards the front legs and along the back towards the rump. Subsequently the winter hair seems to be lost so rapidly that only patches remain.

Normally adult bulls will have their summer coats by June 1. However, one young-adult bull observed on June 25, 1955 was still mainly covered by winter hair.

TABLE 5. SELECTED CHRONOLOGY OF SHEDDING OF WINTER HAIR BY MOOSE.

Date	Age and Sex	Description of presence of summer and winter hair
May 31, 1953	Ad. ♀	Small patch of summer hair on flank.
June 1, 1953	Ad. ♀	Summer hair starting back of the hump and continuing down to the rump. Winter hair floating on the water, indicating active shedding of hair.
June 9, 1955	2 yrs.? ♂	Summer hair on shoulders.
June 9, 1955	Ad. ♂	Summer hair on neck, and back of the ears.
June 12, 1955	Ad. ♀	Summer hair on shoulders, back and rump.
June 13, 1955	2 yrs.? ♂	Summer hair on shoulders, rump and spots on neck.
June 13, 1953	Ad. ♀	Small patch of summer hair just below hump of shoulder.
June 14, 1955	Ad. ♀	Considerable summer hair across shoulders; a patch on flank.
June 18, 1955	2 yrs.? ♂	Considerable summer hair across shoulders; patches on rump and belly.
June 24, 1955	Ad. ♀	Considerable summer hair across shoulders; a patch on flank.
June 25, 1955	Yg. Ad. ♂	Considerable summer hair across shoulders.
July 2, 1955	Ad. ♀	Patches of winter hair on neck, flank, rump and upper part of front leg.

MEASUREMENT OF HOOF IMPRINTS

Sometimes it is impossible to recognize the sex of an individual because it disappears too quickly or it is observed from too great a distance to make out antlers. When it is desirable to determine the sex and/or age, tracks may provide useful clues. Skuncke (1949) shows a table with measurements of hoof imprints of Swedish moose, with data on imprints of calves, yearlings, cows and bulls. Unfortunately he does not provide average measurements, nor does he state on how many individuals the data are based. He obtained these data from a publication by Hemberg (no date mentioned).

Data were tabulated of hoof imprint measurements from animals of known age and sex in Ontario, as well as those from Sweden (Table 6). It will be noticed that calf prints can be reasonably well separated from yearling prints, and that the track marks of bulls can be separated with apparently little overlap from the imprints of adult cows and spike bulls (generally yearlings in Sweden). However, it seems impossible to differentiate the prints of spike bulls from those of adult cows, and those of yearlings from adult cows. This criterion therefore has only limited value as a field technique.

SUMMARY

1. A method has been developed to mark moose with paint. The marking mechanism operates successfully, but paint does not seem to be a suitable medium.

TABLE 6. MEASUREMENTS OF HOOF IMPRINTS OF MOOSE OF KNOWN AGE AND SEX

	Imprints in centimeters											
	Front feet						Hind feet					
	Length			Width			Length			Width		
	min.	means	max.	min.	means	max.	min.	means	max.	min.	means	max.
Cow calf, August, Ontario		6.5			6.0			6.0			5.5	
Bull calf, Sept., Sweden[1]		9.5			8.0			8.5			7.0	
Yearling bull, Ontario		10.0			9.0			10.0			8.0	
Yearling cow, Sweden		11.5			8.5			10.0			8.0	
Adult cows, Ontario (10 specimens)	11.0	12.5	14.0	9.0	10.0	11.5	10.0	11.3	12.7	8.3	10.5	11.0
Adult cows, spike bulls, Sweden	12.5		14.0	9.5		10.0	11.5		13.5		9.0	
Adult bulls, Ontario (4 specimens)	14.0	14.6	15.2	11.5	12.4	14.0	12.0	13.0	14.0	10.0	10.9	13.0
Adult bulls, from fork stage to later antler stages, Sweden	13.0		15.0	11.0		13.0	14.0		15.5	10.5		11.0

1The Swedish data are from Skuncke (1949) who in turn obtained them from Hemberg.

2. Repeat observations and movements during the summer in the water and along shores are discussed. A few observations were made of definitely known individuals; the remainder were made of individuals which were recognized by one or more characteristics. The majority of repeat observations were made at or near the same location and usually on the same or consecutive days. Data suggest that moose may return to the same spot after a certain lapse of time.
3. The percentage of adult bulls appears higher in the study area than under average Ontario conditions. The calf crop appears poor as compared with adjoining regions. Data suggest that continuous protection in a wildlife refuge, resulting in overbrowsed range conditions may be a cause of the situation described.
4. The development of antlers of old bulls is discussed. During May and June the antlers develop very rapidly; brow tines grow faster than the palmated portion of the antlers. By late August the antlers have reached full development.
5. Winter hair is being shed between early May and early July. Generally adult bulls acquire a summer coat faster than cows and yearlings.
6. Measurements of hoof imprints have a limited value for determining age and/or sex.

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DISCUSSION

DR. RICHARD TABER [California]: I would like to ask if in these studies you have observed a yearling dispersal movement in moose.

DR. DE VOS: I cannot give you any information about that.

DR. W. SWANK [Arizona]: I would like to ask this of the group more than the speaker. We have had some trouble with marking our animals. We tried the deer marker, we have used dye, paint and anything else that we thought would stay on the deer. We know that we marked as many as 50 deer in two areas and yet we saw only two or three after that.

MR. STEVENS [Northwest Territories]: I am afraid that I cannot give you much information. We had a program of marking animals from a plane and we got along very well. Of course, in the process we got a lot of the paint on ourselves. We also used some of the dyes, but they did not seem to stick to the coats.

G. C. HALAZON [Kansas]: We used a lacquer. The animals were painted in June and the markings were still visible in October. The secret is that you have to rub the paint well into the hairs, and you have to use a quick drying paint or the paint will mat and the hair will be pulled out.

MR. MOLLER [Idaho]: We have been hanging bells on some of the deer so that we could get some record of movements.

DR. J. V. BUCKLEY [Alaska]: This matter of making paint stay on animals is not unique to the moose. One of our biologists has tried this on large brown bears by using a crossbow with a vial of paint on the arrow point.

BIG GAME DENSITIES AND RANGE CARRYING CAPACITIES IN EAST AFRICA

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Studies of wildlife populations from a quantitative standpoint have generally been lacking in Africa (Worthington, 1954) and there have been few attempts to compare the carrying capacities of the American plains with those of the African veldt. This paper is to report a study of African big game densities on grasslands near Nairobi, Kenya, during parts of 1953 and 1954, to contrast them with some American data, and to offer suggestions in the management of East African grasslands game. An earlier report (Petrides, 1955) has dealt with general land use and preservation problems of East African big game populations and a further publication is planned to provide additional details on the present ecological study. The term "game" is used here to describe the large mammals studied even though there is no hunting in the national parks.

I am deeply indebted to Colonel Mervyn H. Cowie, Director, and to other officials of the Royal National Parks of Kenya, for generous assistance and encouragement in the field. I also wish to thank Drs. Peter I. Tack and Paul A. Herbert of Michigan State University, Daniel L. Leedy of the United States Fish and Wildlife Service, and Charles A. Dambach of Ohio State University for their help in undertaking the project. The work was financed by a Fulbright research grant.

STUDY AREAS

Two study areas, each about 11 square miles in size, were selected in Nairobi National Park, just outside Nairobi, Kenya. They were separated from each other by about three miles at the nearest points. The entire national park is only about 40 square miles and is merely a small portion of the Athi Plains, most of which lie in the Masai Reserve. Game animals move freely across park boundaries into and out of the Plains proper.

The study areas lay between 5000 and 5500 feet altitude in the *Themeda-Acacia* grassland area (Edwards and Bogden, 1951). Despite its equatorial latitude, the altitude of the study areas resulted in a uniformly pleasant temperature. The mean annual temperature at Nairobi is 67°F., with the mean annual maximum and minimum at 78°F. and 57°F., respectively (Gordon-Brown, 1933). The average annual rainfall of about 25 inches is concentrated during two rainy seasons in this region. There are two growing seasons annually. The "short rains" come in November-December and the "long rains" in late March-June.

Study Area A was at the higher elevation and bordered the lower edge of the mountain forest. Four small earthen dams had been erected on this area by the national parks organization. Additionally, water persisted in some streambed depressions throughout the dry seasons. Area B was lower in altitude. The Athi River provided flowing water along one border during most of the year and provided deep pools at all seasons.

On Area A, reddish lateritic soils were important (Table 1), intermixed with darker clays, sometimes listed as chernozems (Gracie, 1930). On Area B, the dark clay soils, varying from gray to black in color, occupied all except a small portion.

The red soils, in general, occurred on the better drained sites. Steep hillsides with shallow rocky soils always were distinctly reddish. The more mature soils occurred on rolling to flat areas. The lateritic soils of this region typically are very absorbent and do not become boggy when wet. They lack a corbonate layer though some have a deep layer of iron concretions (Gracie, 1930).

The black soils were typical of poorly drained sites but also occurred, particularly in intergrading gray phases, on moderate slopes similar in inclination to those elsewhere on the study areas which supported red earths (Table 1). Black soils were not seen, however, on steep land. During dry weather, these black clays developed prominent deep surface cracks. In rainy periods, the gumbo became an exceedingly sticky mass. Typically, the more grayish surface soils are quite acidic though black surfaces are near neutral. The black earths are underlain by a carbonate hardpan (Gracie, 1930).

TABLE 1. PROPORTIONS OF MAJOR SOIL AND VEGETATION TYPE CHARACTERISTICS ON STUDY AREAS NAIROBI NATIONAL PARK, KENYA, 1954

			Percentages	
Topography	*Soil Characteristics*	*Dominant Plants*	*Area A*	*Area B*
Rocky hillsides	Red, shallow	*Cymbopogon-Digitaria*	35	15
Rolling to flat	Red, mature to eroded	*Bothriochloa-Themeda*	25	5
Rolling to flat	Black, seasonally waterlogged	*Pennisetum-Acacia*	40	80
			100%	100%
Proportion of total area at end of dry season (late March, 1954) with over 90% of stubble less than 1½ inches high			65%	20%

Along several seasonally-dry watercourses and the Athi River, tall acacia trees (*Acacia spp.*) grew. On the black and gray soils, there occurred numerous but scattered small whistling thorn (*Acacia drepanolobium*) shrubs which were browsed upon mainly by giraffes. Though the whistling thorn area perhaps should be classified as savannah, in general the study areas comprised extensive open grasslands. Dominant grasses were *Themeda triandra, Bothriochloa insculpta* and, especially on dark soils, *Pennisetum menzianum.* On rocky hillsides, *Cymbopogon pospischilii* predominated while *Harpachne schimperi* and *Eragrostis tenuifolia* occupied eroded and overgrazed areas.

The large wild herbivores occupying the areas were the white-bearded wildebeest (*Gorgon taurinus*), hartebeest or kongoni (*Alcelaphus bucelaphus*), Thomson's gazelle (*Gazella thomsonii*), Grant's gazelle (*Gazella granti*), impala (*Aepyceros melampus*), waterbuck (*Kobus ellipsiprymnus*), eland (*Taurotragus oryx*), giraffe (*Giraffa camelopardalis*), and zebra (*Equus burchellii*). On Area A, there was some grazing also by domestic cattle and sheep. (Residence and limited grazing privileges in the park were allowed several Somali families in recognition of services in the 1914-18 war). In addition, a small herd of hippopotami (*Hippopotamus amphibius*) evidently lived in the Athi River adjacent to Area B. Doubtless they nocturnally grazed a portion of the area but since they were not seen there and no signs of grazing by them were evident on the study area, they have been ignored in this study.

Other conspicuous animals seen on the study areas included the lion (*Panthera leo*), cheetah (*Acinonyx jubatus*), spotted hyaena (*Crocuta crocuta*), silver-backed jackal (*Canis aureaus*), bat-eared fox (*Otocyon megalotis*), baboon (*Papio anubis*), ostrich (*Struthio camelus*), Kori bustard (*Ardeotis kori*), secretary bird (*Sagittarius serpentarius*), helmeted guineafowl (*Numida mitrata*), yellow-throated francolin (*Pternestis leucoscepus*), and harlequin quail (*Coturnix delegorguei*). (Scientific names follow Swynnerton and Haymann [1950] for mammals and Mackworth-Praed and Grant [1952] for birds.)

This report is concerned only with an interpretation of abundance data for the wild and domestic herbivorous mammals observed. The present study was limited to the period in 1954 between mid-January, after the short rains, and late July, after the long rains. A full cycle of a wet and dry season was studied, though fewer observations were made on Area B because of impassable roads there during the rains.

RANGE CONDITIONS

In general, Area A was largely overgrazed while Area B was undergrazed. Evidences of overgrazing on Area A were:

(1) At the end of the dry season, a large proportion (65 per cent) of the area had no grasses over 1-1½ inches tall and much of it was under 1 inch high.

(2) *Harpachne schimperi-Eragrostis tenuifolia* communities were widespread, comprising an estimated 25 per cent of the area.

(3) Young shrubs of several species were invading the grasslands from areas of shallow rocky soils.

(4) The unpalatable rocky-soil grass, *Cymbopogon pospischilii,* frequently was closely grazed.

(5) Exposed bare ground was frequent throughout the red soils portions and there was a considerable accumulation of silt behind some dams installed only a few years previously.

(6) Game numbers in the overgrazed areas diminished as the dry season progressed (see beyond), despite the greater availability of water there.

It did not seem possible that the general overgrazed condition could have been entirely due to the reported heavy use by livestock several years previous. There were no indications of range recovery through the reinvasion of species higher in the successional pattern.

Area B was heavily grassed throughout the study period except for relatively small areas of red soils and a few watering places along the Athi River.

CENSUS METHOD

Direct and complete counts of game animals were attempted from a car, using the dirt roads and tracks where possible but otherwise driving over the open rangelands. Binoculars were used from vantage points to insure thorough coverage and to determine sex and age composition. In a few rocky sections, short side trips were made on foot. The number, sex, age, and location of observed animals were recorded on field maps and tallied later. Censuses were conducted during the early mornings, from about 6:30 a.m. to 10:00 a.m. or, on a few days when game was especially numerous, noon. Travel routes were followed each day in a standardized pattern.

Errors in seeing animals on open grasslands are believed to have been few. The gregarious nature of most species and their usual avoidance of dense brush made most animals reasonably evident upon careful examination of the terrain. Most could be approached rather closely by car. Use of binoculars further insured against omissions. In the sparse whistling thorn on black soils, some animals may have been missed but efforts were made to cover these sections carefully. Some animals also may have been hidden in the trees and brush occurring along some dry streambeds, but these places were typical daytime haunts of lions and other predators and there was rarely any large number of prey animals congregating there. Any errors due to failure to observe animals would result in underestimates rather than overestimates of abundance so that the population data reported here are at least minimal.

Because of the large areas and long census periods involved, some movements of animals occurred within the areas and across their borders. Movements during census periods, however, were never general. It is believed that any errors of this type that did occur were small ones and tended to cancel each other.

During rainy periods, black soil areas and streamcourses were impassable by car and counts had to be suspended, especially on Area B. Eleven complete censuses were made on Area A and seven on Area B. In view of standardized practices, they should all be comparable with one another regardless of possible over-all sources of error.

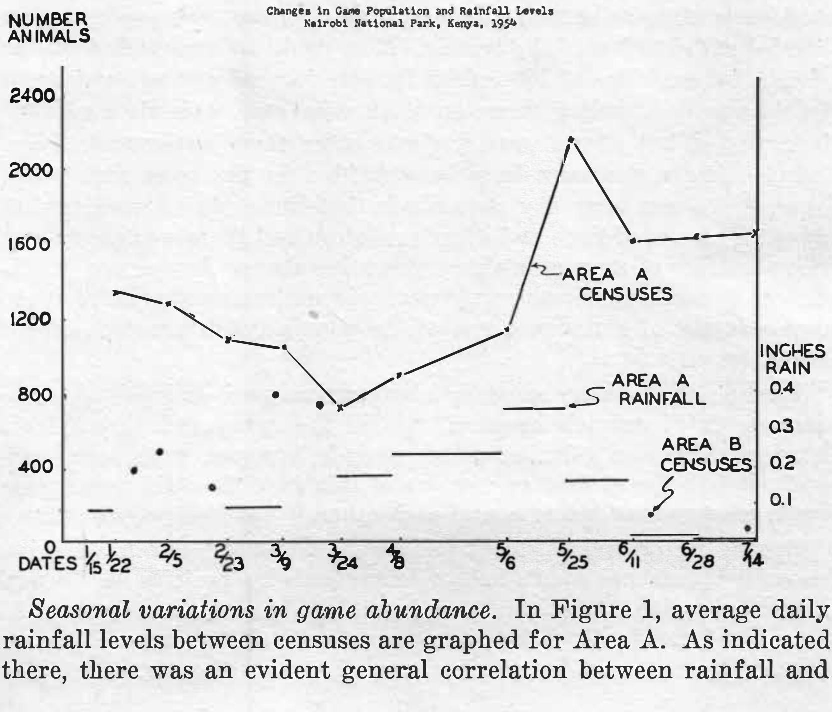
POPULATION LEVELS AND STANDING CROP

Total abundance. In computing the average daily population for each of the eleven-square-mile study areas, each census was taken as representative of a period extending halfway to the nearest adjoining census. The beginnings and ends of the study periods were extended accordingly and were taken as January 15-July 21 on Study Area A and January 24-July 26 on Area B. Counts for each census were weighted according to the number of days in the census period and the summed animal-days for each species was divided by the total number of days (187 days on Area A and 142.5 days on Area B) involved in the study.

Total daily population levels of game animals on both study areas are indicated in Figure 1. On Area A there was a low of about 66 animals per section on March 24 and a high of 200 on May 25. Corresponding figures on Area B were five on July 13 and 73 on March 7. Average daily numerical abundances of the game animals (plus domestic cattle and sheep on Area A) were 134 on Area A and 33 per square mile on Area B (see Table 2).

Figure I

Changes in Game Population and Rainfall Levels
Nairobi National Park, Kenya, 1954



Seasonal variations in game abundance. In Figure 1, average daily rainfall levels between censuses are graphed for Area A. As indicated there, there was an evident general correlation between rainfall and seasonal game animal abundance there. Populations declined during the dry period from early January to late March, with a slight increase in late February when a small amount of rain fell. By the end of the dry season, most of that study area was grazed to a close brown stubble and animal populations were at a minimum.

During the same period, game populations at first decreased and later increased on Area B. Rainfall on Area B is not graphed since none was recorded at the town of Athi River, about two miles away, except during April-June. Then censuses were impossible due to mud as a result of a total of 16 inches of rain. The animal increase on March 7, however, apparently was due to local rains not recorded at the weather station but witnessed on the area on February 19 and 20. Green grass was evident by March 19 and Area B soon became inaccessible.

Although the two study areas were separated by several miles, some of the movements of animals off Area A during the dry season could have taken them into Area B. Actually, the total number of animals on the combined study areas was remarkably stable through the study, fluctuating only between extremes of about 1450 and 1850. Rather than indicating direct migration between the two areas, however, it is believed that these data are merely a reflection of general movements from preferred locations during periods of low forage availability into areas of better grass cover or of greener grass due to local rains.

Preference for red soil areas. There was an apparent preference by game for Area A. Populations there averaged about four times as many as on Area B (Table 2) and virtually ungrazed acreages persisted on the latter plot throughout the study.

TABLE 2. THE STANDING CROP OF GRAZING ANIMALS NAIROBI NATIONAL PARK, KENYA, JANUARY 15—JULY 26, 1954

	Average Daily Abundance		Estimated Average Individual Weights (pounds)	Average Daily Population Weights (pounds)	
	Area A	*Area B*		*Area A*	*Area B*
Eland	2	.2	1,000	2,000	200
Giraffe	9	4	2,500	22,500	10,000
Grant's Gazelle	117	51	135	15,795	6,885
Impala	155	41	150	23,350	6,150
Kongoni	178	110	325	57,850	35,750
Thomson's Gazelle	298	25	45	13,410	1,125
Waterbuck	0	38	450	0	17,000
Wildebeest	387	41	450	174,150	18,450
Zebra	183	66	650	118,850	42,900
Cattle	117	0	800	93,600	0
Sheep	33	0	100	3,300	0
Totals	1,479	377	....	524,805	138,560
Total/sq. mile	134	33	....	47,710	12,600

The most obvious difference between the two districts was the greater proportion of red soils on the A area and the provision of dams there. Additionally, shorter grass cover was available at all seasons on Area A as a result of heavy grazing.

There always were clusters of game in the vicinity of the dammed waterholes on Area A and these places seemed very attractive to game. The heavier grazing pressure on that area, however, did not seem due primarily to water availability since water also was constantly available in the Athi River bordering Area B. It is true that securing water from this source involved penetration of streamside thickets and the danger of possibly encountering predators, but actually a higher abundance of predators was recorded on Area A than on Area B. Furthermore, in June and July, when forage and water were widely available, Area B nevertheless was practically abandoned while Area A maintained high game populations.

The forage growing on red soils apparently was more attractive than that (often of the same species) growing on black or gray soils. There was, within both areas, a regularly greater concentration of animals on red soils and a much closer use of grasses growing on those soils.

The closer cropping of red soil grasses, for some grazing species, actually seemed itself to be an attractive feature, particularly during the rainy season. Thomson's gazelles, wildebeest, kongoni, and zebra, especially, seemed to concentrate in places where very short grasses grew. They gradually widened such areas by close grazing. This arrangement may have been influenced by a feeling of greater protection from predators. In any event, it resulted in a greater use of red soil areas and pointed to the importance of subclimax grass associations to some animal species.

The evidence points to an animal preference for red soil areas because of edaphic factors probably affecting the palatability of forage. As discussed beyond, this raises a problem in game management in this region.

Weights of standing crops of grazing animals. Because so little data are available on the subject, an attempt was made to estimate the total weights of the average populations of grazing animals (Table 2) and to compare these with similar data for other areas (Table 3).

So far as is known, average weights for East African mammals have not been determined. Those selected in Table 2 for each species, therefore, are approximate averages of occasional data given in such sources as Bryden (1899). For the small local breeds of domestic stock, weights were estimated arbitrarily. All of these weights apply

TABLE 3. GRAZING CAPACITY DATA FOR SOME NATURAL BIG GAME AND LIVESTOCK RANGES

Wt. of Animals per sq.mi.	No. Animals per sq.mi.	Size of Area sq. miles	Species and Range Conditions	Location	Reference
1,000	9[1]	1,000	Antelope 64% Mule deer 36%	Oregon	Ruth, 1939[2]
1,500-3,200	11-23	....	Mule deer, average on various ranges	California	Longhurst *et al.* 1952
3,200	27	1	White-tailed deer where range being damaged	N. Michigan	Van Etten, 1955
3,300	10	600	"Bush country'	Tanganyika	Pots and Jackson, 1952
5,200	6[1]	30	Bison 70%, elk 16%, mule deer 6%, cattle 8%	Nebraska	Ruth, 1939
5,800	48	2	White-tailed deer at proper density	S. Michigan	O'Roke & Hamerstrom, 1948
8,000	80	....	Sheep yearlings, maximum stocking	Montana	Woolfolk, 1949[3]
9,600	80	....	White-tailed deer, maximum overbrowsing	Wisconsin	Martin & Krefting 1953
11,000	20[1]	....	Average 50% cattle; 50% antelope	Texas	Buechner, 1950
12,600	33	11	Nine herbivores, moderately grazed	E. Africa	This study
14,000	21[1]	29	Bison 50%, mule deer 20%, elk 7%, bighorn	Montana	Ruth, 1939
20,000	20	....	Cattle, average for all virgin range types	West. U.S.	Watts *et al.*, 1936[4]
20,800	35	41	Bison 30%, elk 51%, mule deer 13%, antelope 6%	S. Dakota	Cahalane, 1952 Drury, 1950[2]
21,000	21	....	Cattle on excellent range	Oklahoma	Soil Cons. Serv., 1949
21,000-32,000	21-32	....	Cattle, average for *Themeda* grasslands	Kenya	Henderson, 1950
17,000	17[1]	20	Bison	Arizona	Walmo. 1951
25,000-30,000[5]	80-90	....	Herbivores; est. average for *Themeda-Acacia* area	E. Africa	This study
28,000	28	....	Cattle, average for virgin tall grass prairie	West. U.S.	Watts *et al.*, 1936[4]
47,700	134	11	Ten herbivores, heavily grazed	E. Africa	This study
75,000	75	....	Cattle at "far too high" a density	Kansas	Weaver & Darland, 1948

[1]Author's comments indicate that the stocking rate given is considered to be at an optimum level.
[2]Animal numbers and apparently applicable acreages used.
[3]Numbers of animals derived as animal-months x 12; average weight 100 lbs.
[4]Converted from acres per animal unit per year at the rate of five units per steer.
[5]At an estimated average 332 pounds per head of game.

primarily to adults and doubtless are somewhat high as population averages. No suitable method is available to correct for this source of error unless one merely multiplies total population weights by some factor. In view of essentially rough calculations in Table 3 involving the same sort of error for other species, however, no adjustments for all-age averages have been made in the population weight computations of either Table 2 or 3. Average weights of about 47,700 pounds per square mile for Area A and 12,600 pounds for Area B were computed (Table 2).

In appraising the population abundance and weights as related to range conditions on the two areas of this study, observations indicated, as previously discussed, that much of Area A, especially on the lateritic soils but also on some black clays, was badly overgrazed. Except for small areas of red soils, Area B was undergrazed.

What the optimum levels of grazing pressure might be on these areas cannot be accurately determined. Henderson (1950) believed that 20-30 acres per domestic cow is average in the general *Themeda-Acacia* type. The average weight per head of game in Nairobi National Park was 322 pounds on Area A and 368 pounds on Area B, with a total average of about 332 pounds. If Henderson's cattle weighed 1000 pounds each, this would indicate an average carrying capacity of 70 to 110 head of game per square mile. Although precise evidence is lacking, general observations on the study areas indicated that the average carrying capacity for game in Nairobi National Park would be in between the levels found on the two study areas, at about 25,000-30,000 pounds or 80-90 head of game per square mile.

Table 3 is presented so that comparisons of the African data could be made with some from the United States. No attempt was made to undertake a complete investigation of the literature in compiling Table 3. An effort was made, however, to restrict information there to (1) wild as opposed to improved pasturelands, (2) data apparently pertaining to year-around animal use (or nearly so), (3) cases where all species (wild and domestic) using the range were considered, and (4) areas in which forage use and feeding pressure were balanced (except for a few examples of overuse as a contrast).

In computing population weights for Table 3, the following animal poundages of grown animals were used as averages: domestic cattle 1000, bison 1000, elk 530, bighorn sheep 180, mule deer 140, white-tailed deer 120, domestic sheep 120, antelope 100. These data were derived from a variety of sources (especially Rasmussen's ratios in Stoddard and Smith, 1942). While they may not be entirely accurate for all ranges, they should at least permit the determination of the order of magnitude of the weights of animal assemblages listed in Table 3.

One of the most interesting comparisons, it is believed, is between the data of this study and the carrying capacities of American grasslands as reported by Watts *et al.* (1936) and by the Soil Conservation Service (1949). Their data are in good agreement that the properly-utilized United States plains could carry an average of 20 or 21 head of cattle per square mile, with up to 28 per section on the most productive prairies. Since Rasmussen (in Stoddard and Smith, 1943) considers bison (*Bison bison*) to be equivalent to range cattle in terms of animal-units, it seems likely that the former herds of American buffalo roamed the plains at approximate densities of 20-28 per square mile (where other game species also occurred, buffalo numbers must have been fewer but total populations larger). The estimated East African plains carrying capacities are considerably higher than those of American grasslands in terms of numbers of animals per section (80-90 rather than 20-28 plus) but when total weights are considered the two are approximately equal.

GAME MANAGEMENT PROBLEMS ON EAST AFRICAN GRASSLANDS

The East African grasslands have great productivity and there is an advantage in having a greater variety of smaller game animals than prevailed on the American plains. But care in managing these valuable resources must be taken not only to see that game abundance is maintained at a high level but also to see that the grassland habitat is preserved from overuse.

For Nairobi National Park, in addition to general policy matters discussed elsewhere (Petrides, 1955), the following recommendations are made: (1) Dams should be built in grasland areas only where it is deemed essential that natural situations be altered, but if planned, they should be placed away from red soil areas. (2) Salt should be used, at least temporarily, in the black soil areas to encourage greater use of pasturage there and to decrease pressure on the red soil forage. (3) Fenced exclosures should be built to preserve sample areas from grazing so that they can serve as guides to range condition. (4) Further studies of soil-forage characteristics and of the feasibility of lime application in black soil areas should be undertaken if it is felt desirable to alter natural conditions. (5) The services of professional wildlife biologists should be secured to advise in the management of the game resources.

Game in East Africa is an important economic asset supporting the important tourist and safari industries. In addition, however, the population studies made here seem to verify that there is a good potential return from wild game in terms of meat per acre carried through a seasonal cycle. Considering also the rapid growth and early maturity that often prevail in game species, it may well be that the productivity of wild game on East African ranges exceeds by a considerable amount that of domestic livestock there. If suitable areas outside national parks can be located where tribal authorities will cooperate in controlled slaughters and where game herds are relatively sedentary, further thought perhaps should be given to active management of wild game as a sort of easily-managed and disease-resistant permanent food source.

SUMMARY

Two areas, each eleven square miles in area in the *Themeda-Acacia* grasslands near Nairobi, Kenya, were studied in 1954 during a seven months weather cycle of dry and wet seasons to determine relationships between large grazing animals and the natural vegetation. On one area, there were populations of eight wild and tow domestic species which varied in abundance between 66 and 200 and averaged 134 animals per square mile. On the other study plot, numbers of eight species varied between five and 73 and averaged 33 head per section. The greater abundance on the first area apparently was due to a preference for food plants growing on the red lateritic soils of that district over those of the calcareous black clays which predominated on the second plot. Seasonal abundance of animals was correlated with rainfall and the availability of green forage.

Using estimated average weights, an average of about 48,000 pounds of grazing animals per square mile was calculated for the first area. A corresponding figure of about 13,000 pounds was calculated for the second. These East African data are compared with carrying capacities calculated for various American big game ranges. Though the Kenya veldt apparently can support 80-90 animals per square mile in contrast to 20-28 animals per square mile on the American plains (or a few more where animals smaller than buffalo were present), the weights of grazing animals which can be carried on a sustained basis per square mile are roughly equal in the two grassland areas.

Big game populations in East Africa supply a basis for the valuable tourist and safari trades. On the basis of the population figures and other data, however, game animals perhaps should be given greater consideration on tribal lands as disease-resistant and easily-managed livestock. Several suggestions are offered for the management of big game in the national parks of East African grasslands.

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DISCUSSION

DR. WM. SHELDON [Mass.]: Do you know of any instances in Africa where due to overgrazing, there has been any kind of die-off of big game populations?

DR. PETRIDES: I don't know of any that definitely has been assigned to that cause. I feel that overgrazing is a very important factor but evidence of direct type is difficult to come by. Any animal that is dead on the plains will last only a few short hours, if that long, as the vultures lose no time in leaving nothing but the bones. To find dead animals is difficult and to attempt to relate the death to a specific cause is even more difficult.

PATTERNS OF SOCIAL BEHAVIOR IN BIG GAME

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Patterns of social behavior were compared in the wapiti, *Cervus canadensis nelsoni;* moose, *Alces americana shirasi;* chamois, *Rupicapra rupicapra;* and wild boar, *Sus scrofa europ.* These species were selected for comparison because of considerable differences in their social behavior.

The natural history of these well known game animals has been thoroughly worked upon in the past. I should like to mention the work of O. Murie on the wapiti, R. L. Peterson and J. McMillan on moose, and M. Couturier on the chamois. There is, however, very little analysis of the group behavior of these ungulates in the literature.

Social behavior of wapiti has been studied by the author in a long range study covering more than eight years (Altmann, 1951, 52, 53). More recently the moose, the chamois, and the wild boar have been studied in respect to their social patterns.

The research was sponsored by the New York Zoological Society with the exception of the moose study which is carried forth under a grant from the National Science Foundation.

Differences in the group behavior of these species were observed. Size and sex distribution of groups, spacing, leadership, communication, reaction to disturbances, and diurnal schedule of activity and rest were compared, as shown in Table 1. These differences persisted regardless of whether the group traveled, rested, or grazed.

The wapiti maintain wide spacing—often to the point of losing visual contact with each other. The chamois stay rather close together, and the wild boar, typical contact animals, stay so close together that they have bodily contact much of the time.

The communications are adapted to the natural spacing. The wapiti use loud calls and clearly accentuated signals. Their warning call is a bark followed by "stiff walking" (Altmann, 1953). The wild boar uses a low grunt audible only at close distance. The chamois' warning is a sharp high whistle. The moose usually uses gesture as a means of communication, very rarely sound. The position of the ears and the facial expression indicate the moose's friendly or unfriendly reactions.

In the reactions to disturbances, we find, at the extreme end of sensitivity, the chamois with an instant reaction. Their very acute perception of danger is based on their sensitivity to ground vibration and their keen sense of smell. The elk are next in reaction speed. The wild boar take a brief pause before their flight or aggressive action.

TABLE 1. SOCIAL ORGANIZATION OF FOUR UNGULATE SPECIES IN SUMMER

	Wapiti	Moose	Chamois	Wild Boar
Size of group	Medium to large	Solitary	Medium to small	Small family groups
Sex	Sexes separate	Cows with or yearling	Both sexes	
Spacing:				
In group	Wide		Close	Very close
Between groups	Wide	Variable	Close	Very wide
Leadership:				
In female group	Mature cow elk	Mature moose cow	Mature female	Mature sow
In male group	None	Older bulls		
Communication	Calls and sign stimuli over long distance	Gesture over close dsitance	Warning whistle. Few calls	Warning grunt. Few calls
Reaction to disturbances	Very fast reaction in flight	Delayed reaction	Instant reaction in flight	Reaction after short delay
Getaway type	Noisy, in unison	Silent withdrawal	Noisy, group breaks often in flight	Noisy, very close group in flight
Schedule:				
Feeding	Daytime	Dawn and dusk	Daytime	Night and dusk
Resting	Night and noon	Night and noon	Night	Daytime

The moose have a definitely delayed reaction preceding a silent withdrawal. The other species make a noisy getaway.

The flight distance, which has been claimed to be typical of a species, was found to be subject to great variability according to habitat and situation. Closeness to obstacles (fence, for instance), and disturbances made the animals more wary than wide-open spaces. The smallest flight distance found by the author was in elk and moose on the summer range.

The diurnal schedule of feeding and resting was characteristic for the species. The elk and chamois fed in daylight and rested at night. The moose fed at dawn and dusk and rested at night and noon. The wild boar was under cover in daytime and emerged to forage at night.

The seasonal changes in the social structure of wapiti, moose, and chamois are shown in Table 2.

The largest groups of elk, moose, and chamois are found during the winter months. These groups are loose aggregates that do not show cohesion and social order. The wapiti and moose aggregates dissolve in spring and the sexes separate. In the chamois, the bucks remain within the smaller bands until late in summer.

The migration of elk to the summer ranges begins with the onset of the snow melt. Some of the moose population also drift into the

TABLE 2. SEASONAL CHANGES IN GROUP STRUCTURE OF THREE SPECIES OF UNGULATES

	Wapiti	Moose	Chamois
Winter	Very large aggregate (up to 12,000 head). Both sexes	Small aggregate (2-19 head). Sexes frequently separate	Medium herd (15-40 head). Both sexes
Spring	Small to medium bands (5-50 head). Sexes separate on migration. Long migration (20-50 miles).	Solitary or with younger satellite. Limited migration (5-15 miles)	Herds split into small bands. Withdraw to and above timberline (1-5 miles)
Summer	Females form large summer herd with calves (150-1,500 head). Males form small bull groups	Solitary cows with calf or yearling Bulls solitary or with satellite	Medium herds. Both sexes together
Fall	Harems formed (5-15 elk cows, 1 bull)	Bull drives solitary cow	Bucks separate and one buck joins small band of females, marks territory

higher elevations, but this migration is of limited nature—in numbers as well as in distance.

The chamois withdraw gradually up to and above the timberline early in summer, when the local cattle herds invade the mountain pastures (Alps).

Medium sized elk nursery herds join forces on the plateaus of the summer range to form huge summer herds, up to 1,500 head. The moose cow brings up her calf in solitary fashion. Her aggressive behavior against any intruder, human, horse, coyote, or other moose, justifies the assumption of territoriality at this season.

As fall approaches, the larger herds break up. A more detailed picture of the role of the male and his group associations is seen in Table 3.

TABLE 3. THE ROLE OF THE MALE IN THREE SPECIES OF UNGULATES DURING THE RUT

	Wapiti	Moose	Chamois
Pre-rutting Season	Unrest. Velvet is rubbed. Satellites are driven off. Bugling and wallowing begins	Restless stage. Velvet is rubbed. Big bulls are solitary	Bucks leave family group. Become solitary
Rutting Season	Mature elk bulls join female bands. Form and defend harems. Bugling and aggressive behavior	Bull responds to call by moose cow. Drives one female. Individual mating. No harem, but defense against intruders	Search and mark shrubs in territory. Form harem. Defend it.

A period which I shall call the pre-rut is characterized by unrest and more irregular activities in the males. The one and two year old elk, moose and chamois males are driven out of their summer associations. Velvet rubbing and increased use of wallows is observed in bull elk and bull moose. The chamois bucks wander restlessly through the mountain slopes. They begin to mark shrubs and tree stumps with the secretion from the now activated glands behind the horns. Thus, the chamois bucks establish their territory.

When the rutting season is in full swing, the wapiti and chamois males form harems. The mature male joins a small band of females, drives them and keeps other males at a distance.

The moose bull responds to the call of a moose cow, he drives the cow, individual mating takes place, but no harem is formed.

Fighting occurs between the males in all three species. The seriousness and duration of the fighting is generally overrated. A considerable amount of formal sparring and intimidation display takes place. The retreat of one partner, either before the fight gets under way or after a few blows, terminates the majority of male encounters. Serious, persistent battles will result only when well-matched opponents are involved.

The role of the young in the group is shown in Table 4. The wapiti cow deposits and hides the calf after birth. She grazes nearby, often using a calf pooling system (Altmann, 1953) for the calf up to almost three weeks of age.

TABLE 4. THE ROLE OF THE YOUNG IN THE GROUP

	Wapiti	Moose	Chamois	Wild Boar
Birth	Secluded but in proximity to herd	Solitary	Within herd	Within herd in thicket
Activity	Calf is left alone or in pools for 14-20 days	Follows mother	Follows mother	Trails sow with litter mates
Sleep	Spaced	In close contact	Spaced	Pile up in sleep and rest
Herd integration	Gradual within 21 days	None	Is always in herd	Family-bands (2 litters)
Enforcement of signals	Elk cow nudges calf, rarely strikes with foreleg. Threat: ears fold back, head raised	Moose cow pushes calf, crowds it. Threat: ears fold back, foreleg is lifted	Very little threatening seen	Adults rush and bite young Littermates fight for dominance
Reaction to intruders	Flight or dodge, shielding pattern by mother. Calf follows stranger	After seconds of hesitation, cow fights off intruders. Calf follows them	Warning whistle, take off with herd	Abrupt grunt by sow. Pigs dodge, lie motionless
Games and playing	Tag and rushing games	Push and splash (water) games	Jumping and butting among kids	Mock fights and rushing games

This system is not unique for elk. R. Verheyen[1] reports from obser-

[1]As reported by E. Pinner, Germany, in unpublished communications, 1955.

vation in the Belgian Congo that hippopotami maintain nursery-pools watched over by a number of females.

While resting or sleeping, the groups may be either spaced widely, as in wapiti and chamois, or in close bodily contact as in the wild boar. The moose calf usually rests in close contact with its mother.

No evidence was found for the existence of "guards" being posted in chamois herds, as was generally believed in Europe. Resting in steep country, the chamois doe locates herself in a downhill position from her young.

Enforcement of signals from mother to the young varies, but the usual type in elk cows is a gentle nudging, rarely a strike with the front leg. In the wild sow, a violent rush and bite is the most common way of dealing with her pigs. Chamois does exhibited very little tendency to threat or interfere with the activity of the young. Moose calves were pushed carefully and, at times, crowded into a stream or onto a steep river bank.

In the reaction to protect the young against intruders, the moose cow is the most aggressive and persistent, the wild sow the fastest one to strike. The elk cow runs off to leave the young calf, when frightened, but often uses an elaborate shielding pattern (Altmann, 1956).

Playing games and playful exercise have been observed in almost all young ungulates. The games of elk calves are at times joined by the whole herd, as is beautifully shown in the Disney film on the Olympic-elk, filmed by the Crislers. Snowdrifts and shallow water are releasers of such play interludes in the elk tribe. Likewise, in the wild pigs, play activity is a sign of well-being and good health. Poorly nourished animals do not play. The lone moose calf plays around the mother, twin moose calves play with each other. Meyer-Holzapfel (1956), in a paper which deals with an analysis of play in zoo animals, states the young ungulates build most games around the "flight" topic. My work corroborates this, although the topic "fight" also plays a part in the case of young chamois and wild pigs.

The social structure of an animal group is sometimes more clearly recognizable when the group is subjected to a test situation. Such "social test" can be a naturally occurring situation or a man-made one. I used only the former in the research reported here.

In Table 5 will be found some of these test situations lined up. In a narow passage between rock ledges, for example, the elk herd slows down and the elk of lower social rating wait to let the animals of higher ranks pass first. Similar conditions were noted in the chamois groups. In moose there was no crowding and, therefore, no dominance visible in comparable situations.

TABLE 5. SOCIAL TEST SITUATIONS

	Wapiti	Moose	Chamois
Narrow trail or passage	Low ranking elk have to wait	No dominance seen	Mature males and females pass first
River crossing	Mature female leads. Groups cross together or wait for stragglers	Solitary crossing. No hesitation	No cases observed
Saltlick	High ranking elk enter first. Lowest ranks stay in secondary lick.	Enter solitary. Chase younger moose away	No cases observed
Severe storm	Shelter in tree-group or deep timber. Mature cows go first	Enter shelter under big tree. Solitary	Shelter in rock ledges. Older chamois get priority

When elk groups got ready to cross a swollen stream in their spring migration, a mature elk cow would be in the leading role. Most significant was that she determined the place and time to cross, and the length of the waiting for stragglers. The swollen stream did not represent any test situation for the moose or calf, both being proficient swimmers.

The most pronounced test situation is foünd in the saltlicks, where wapiti and moose will enter according to priority and rank. Some of the lower ranking animals have to stand excluded for so long that they stamp and paw the ground and start small side-licks. Mature females, with or without young, furnish the high-ranking animals.

In elk, the calf of the high-ranking elk cow is included in the privileges attached to the position. For instance, when a severe hail storm hits the herd on the summer range, the limited tree shelters are occupied by the mature elk and their calves, the yearlings and lesser elk have to stay outside. The same was true for the chamois. Such situations, which provided a test for elk and chamois herds did not ruffle the wild boar which are of the "contact" type. They filed smoothly into narrow passages, constantly in closest contact with each other.

The question of a non-conforming individual within the ungulate groups has been of special interest to me. Is there ever, within the normal animal group, an "outlaw"? In domestic animals we speak of an outlaw frequently, but this is done in the sense of man-made law. I am speaking here of an outlaw from its own social group. Aging or injured animals are found outside the group, and the male yearlings and two year olds are also "outside" when they are driven off at rutting time. However, no clear case of open antagonism of one individual against the herd was observed. Further studies will be carried out to illustrate this question.

SUMMARY

Patterns of social behavior in free ranging elk and moose of the United States, and of chamois and wild boar of Europe were compared.

The organization of the species in respect to space, leadership, communication, and reaction to disturbances was noted. The seasonal changes of the groups were contrasted as to size of group and distribution of sexes.

The role of the male was traced from winter situation to the peak of activity in the rutting season.

The place of the young in the group was shown to vary in respect to activity, closeness to its mother and herd integration.

The enforcement of signals between mother and young, and the reaction to intruders was described.

In the execution of games and play activity, it was seen that locomotion, in general, and flight, in particular, were the leading topics. Playful fighting appeared in the young of chamois and in the wild boar pigs.

Social test situations were used to reveal the social structure of the groups. Narrow passageways, river crossings, saltlicks, or storm shelters provided such information.

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DISCUSSION

DR. RICHARD TABER: I am wondering if strength or psychological dominance beyond the productive sexual activity is liable to be an important factor.

DR. ALTMANN: I have tried to point out that leadership and dominance are two different things, at least in my usage of the language. I pointed out that the females in most of these species that I described were in leadership. Possibly you should elaborate on your point a little more for I am afraid that I do not follow you.

DR. RICHARD TABER: We have been told that, in relation to a leader, the large red deer stags are still strong and that they can hold a harem long after they are not capable of producing offspring in their harem.

DR. ALTMANN: I have had quite a bit of experience with Red Deer because I grew up in the forest with red deer.

In that respect, the wapiti is very much like the Red Deer, in that, although there may still be a bull owning and defending the harem, he may also have a great number of cow breeders. He may not make any marked progression but yet he may be in possession of the herd.

DR. RICHARD TABER: With regard to this question of fighting among male animals, we have observed male deer and we see that dominance among male deer is established long before the breeding season. We feel that the purpose of fighting among deer is not to establish authority but it is a matter of sexual stimulation.

I would like to ask a questions now with regard to leadership among the females, among the elk for example. If the adult female is the leader then what is the order at feeding?

DR. ALTMANN: I am afraid that I cannot help you there because I do not have any observations at all on that point.

POSTCONCEPTION OVULATION IN ELK[1]

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Several investigators have examined elk (*Cervus canadensis*) ovaries with the intent of obtaining information on reproductive performance, similar to that published by Cheatum (1949) for white-tailed deer. In these elk studies two corpora lutea per pregnant female were often found. Since elk characteristically give birth to but one calf, the origin of the second corpus luteum provides an interesting problem. The purpose of this paper is to present data on the frequency and chronological sequence of events leading to the formation of two corpora lutea.

DATA

Over 100 pairs of ovaries were examinea by the authors. Of these, 84 pairs were from mature, sexually active cow elk, collected in Washington, Montana, and Oklahoma. The Montana Wildlife Cooperative

[1]Financed in part by the State of Washington Department of Game and Montana Cooperative Wildlife Research Unit.

[2]The authors wish to express their gratitude to Dr. I. O. Buss, Washington State College, Dr. R. K. Meyer and H. W. Mossman, University of Wisconsin; Dr. E. L. Cheatum, State of New York, Conservation Department, Dr. O. W. Tiemeier, Kansas State College and Dr. P. L. Wright, Montana State University, for assistance in preparation of this manuscript.

Research Unit provided a few additional samples collected by M. S. Morris. In addition, Gaab (1953) supplied information concerning the number of corpora lutea in 205 pairs of ovaries of pregnant elk collected from the Yellowstone National Park herd.

Analysis of the data from these 289 pairs of ovaries showed that 61 to 84 per cent of the various groups of ovaries from these different areas contained two corpora lutea (Table 1). Sixty-six per cent of the entire sample had two corpora lutea. The variation among samples is in part a result of the time at which each specimen was collected. Collections made early in the breeding period contained a higher percentage of ovaries with one corpus luteum than those collected later. Also the fact that the material was reported by several different invetsigators, who were observing the ovaries for different reasons, might have had some effect on the results.

TABLE 1. OVARIAN DATA FROM ELK HERDS OF SEVERAL LOCALITIES

Locality	Number of Pairs of Ovaries	Number of Animals with One Corpus lutem Per Pair of Ovaries	Number of Animals with Two Corpora lutea Per Pair of Ovaries	Corpora lutea per Ovary: Two in One Ovary	Corpora lutea per Ovary: One in Each Ovary	Percent of Animals with Two Corpora Lutea
Blue Mountains, Southeastern Washington	32	11	21	13	8	66
Yakima Wenas Area, Central Washington	31	5	26	14	12	84
National Bison Range, Montana	11	2	9	5	4	82
Wichita National Wildlife Refuge, Oklahoma	10	3	7	3	4	70
Yellowstone National Park, Wyoming	205	79	126	10	116	61
TOTAL	289	96	189	45	144	66

Most of the ovaries obtained by the authors were collected from viscera left by elk hunters where they had dressed their kills. A small number of animals were killed throughout the year to provide ovaries of animals in specific stages of ovarian activity needed to complete the cycle. Histological examination was made of at least one pair of ovaries in each important phase of the estrous cycle.

CHRONOLOGICAL OVARIAN ACTIVITY

Analysis of these ovarian samples augmented by field observations of breeding behavior, suggested that ovarian activity followed a specific chronological sequence. This apparent orderly procession of events leading to the formation of two corpora lutea is presented in Table 2. Variation of individual animals caused overlap in the designated time periods. Concentration of certain categories occurred as a result of the time of collection. Hunting season collections provided more material than collections at other times. The percentage of samples collected with two corpora lutea is less than the maximum because some animals were killed prior to the time the second corpus normally would be formed. Evidence which suggests that some of these pregnant animals might have developed a second corpus was found in the development of a series of postconception follicles. All stages of developing follicles were found in pregnant animals. The data can be divided into four categories, (1) anestrus, (2) proestrus, (3) estrus, and (4) pregnancy.

TABLE 2. CHRONOLOGICAL SEQUENCE OF OVARIAN ACTIVITY AND CORRESPONDING EMBRYONIC DEVELOPMENT

Ovarian structure	August and September	October	November	December	January through July	Total	Embryo or etraembryonic tissue
1-3 large Follicles (7-9 mm.)	1					1	Absent
Single large Follicle (8-17 mm.)	2	5				7	Absent
Primary Corpus Luteum, No Follicle > 4 mm.						1	Absent
Primary Corpus Luteum	8					8	Absent
Follicles > 5 usually one (6-10 mm.)		4				4	Present
Primary Corpus Luteum present, secondary present or forming, Follicles usually < 5 (2-10 mm.)	6		11	28	8	53	Present
Single Corpus Luteum Pregnancy well advanced					5	5	Present
TOTAL	3	24	11	28	13	79	

Anestrus and proestrus. The anestrus and proestrus phases are not important to the problem, but are included to complete the picture of the ovarian cycle. Anestrus ovaries were characterized by the absence of corpora lutea, or Graafian follicles over two millimeters in diameter. Ovaries in the early part of proestrus were characterized by the presence of several follicles ranging in size from seven to nine millimeters. One pair of early proestrus ovaries collected in August shows this condition (Figure 1a). Five pairs of ovaries representing a later stage of proestrus characterized by one large follicle (8 to 11 millimeters) were collected in September; all but one of the early follicles had apparently regressed. This pattern of follicular development noted for elk is comparable to conditions in other mammals (Marshall, 1952).

Estrus. In six pairs of ovaries collected at, or near, ovulation which indicated estrus, no evidence was found of more than one follicle being involved. One pair of ovaries (Figure 1b) collected shortly

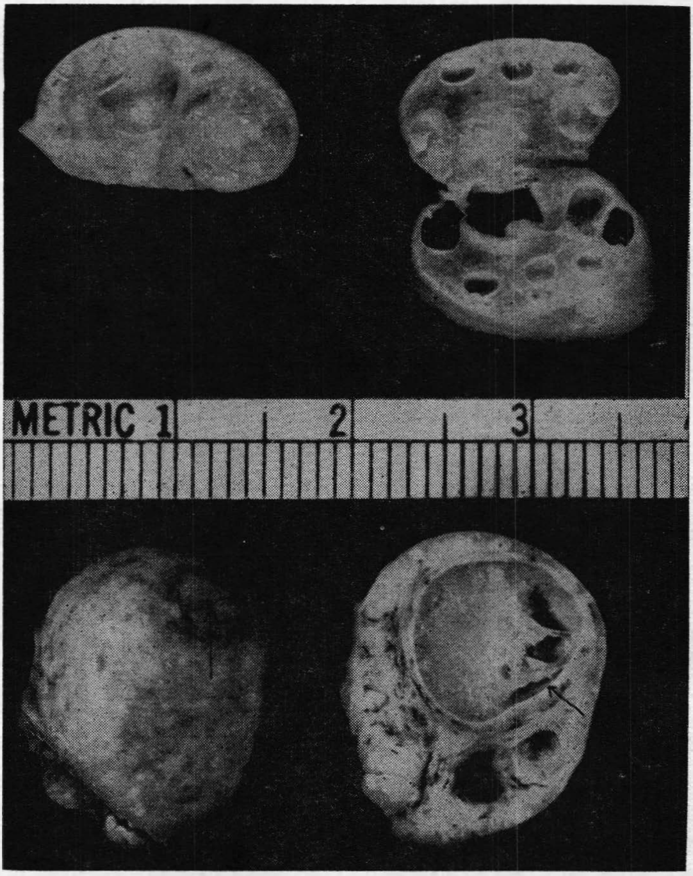


Figure 1a. Cross section of the right and left ovary of a three year old cow elk killed August 20, 1952. Pigment spot from last years pregnancy is visible in right ovary. Two follicles present in left ovary. This represents the early stages of proestrus.
Figure 1b. Internal and external view of right ovary of a one and one-half year old elk killed October 30, 1951. Rupture site visible in external view, bulge due to formation of luteal tissue. Internal view shows ring of luteal tissue forming around periphery of follicle wall.

after ovulation, as indicated by the freshly ruptured follicle, contained only one follicle. This follicle had developed to approximately 17 millimeters. This may be slightly larger than average, as the ovary was larger than those usually found in elk. These data indicate that during estrus, only one follicle normally matures and ruptures.

Observation of breeding behavior of elk in pens at the National Bison Range (Halazon 1952, 1954) plus the data from ovarian collections, suggests that estrus occurred from late September into November but was most frequent early in October. Estrus would probably have been repeated beyond early November if pregnancy had not intervened. Some evidence to support the fact that elk may be seasonally polyestrus has been obtained from penned animals; also, embryos collected from animals in the Blue Mountains of southeastern Washington during late hunting seasons (December, January) contained a few specimens apparently younger than the rest. Four embryos taken the 17th of December, 1951, had an average crown-rump measurement of 135 millimeters. Another embryo taken the same day in the same area had a crown-rump measurement of 57 millimeters.

Period of Pregnancy. This stage of the cycle is normally concerned with the formation and development of the embryo and accessory organs. In elk, the picture is often complicated by the development and maturation of a second series of follicles resulting in a second corpus luteum. The following sequence of events is suggested by the data:

(a) Postconception follicular development. As has been discussed, only one follicle was observed at the time of ovulation. Following conception a second period of follicular development was observed during which one or more follicles over five millimeters were present. The preconception follicles appeared to develop to a larger size, as measurement of 12 postconception follicles showed a size range of 6 to 10 millimeters, somewhat smaller than the 8 to 17 millimeter size range of seven preconception follicles. Measurement of three preconception follicles at or near ovulation showed that mature initial follicles were in the size range of 10 to 17 millimeters. A size discrepancy between apparent primary and secondary corpora lutea is even more obvious as will be shown later.

(b) Postconception ovulation. Following this second period of follicular development, one follicle matures, resulting in ovulation. This postconception ovulation can be dated in relation to the primary ovulation. In one pair of ovaries (Figure 2a), collected at the time of ovulation as indicated by the fresh rupture site and the evacuated follicle, the primary corpus luteum was fully formed and extraembryonic tissue was found in the uterus. The embryo was not visible macroscopically. This may have been because the tissue was not fresh,

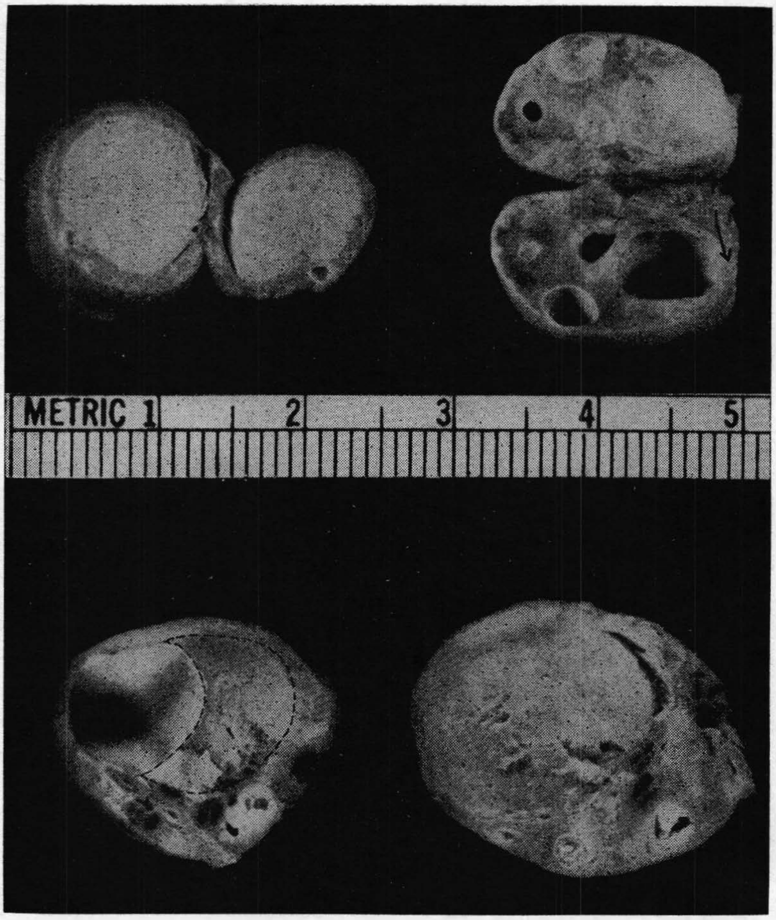


Figure 2a. Ovaries of a three and one-half year old elk taken October 29, 1950. Primary corpus luteum visible in left ovary. Freshly ruptured follicle present in right ovary.
Figure 2b. Internal view of right and left ovary of a five year old elk killed November 2, 1951. Left ovary shows newly found luteal tissue (shaded area) in recently ovulated post-conception follicle. Primary corpus luteum present in right ovary.

having laid in the woods for a period of time before discovery. The other specimen (Figure 2b) collected within a very short time after second ovulation, contained a partially formed secondary corpus luteum and the fully formed primary corpus. In this animal a small embryo was visible. Thus apparently the second ovulation occurs at about the time that the embryo becomes macroscopic (Table 2).

As mentioned earlier the percentage of animals collected with two corpora lutea depends somewhat on the time of collection. However, there was a certain percentage of animals that did not exhibit secondary ovulation. The ovaries of five animals collected with pregnancy well advanced contained only a single corpus luteum. Also one animal collected postpartum, contained only one corpus.

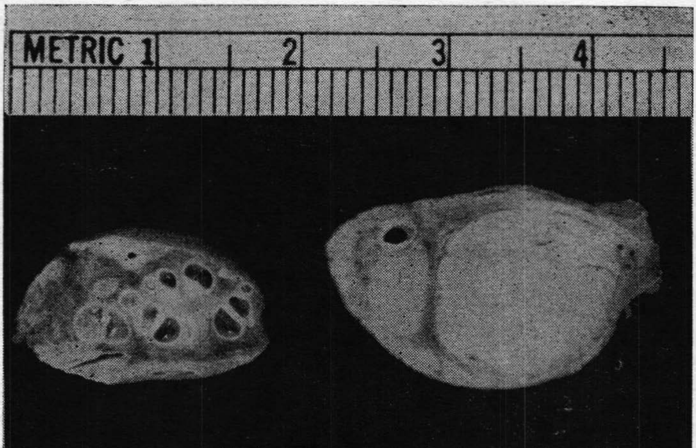
The second ovulation can readily be distinguished from twinning since the complete formation of the primary corpus luteum and embryo indicate clearly that conception had occurred as the result of an earlier ovulation. Further, twinning is not common in elk (Kittams 1953). Twin embryos were found only once during this study. In two additional cases two corpora lutea, apparently in the same stage of development, were present, suggesting the possibility of twinning; however, no embryonic tissue was visible.

Accessory corpora lutea have been described in the wild Norway rat (Hall 1952) and porcupine (Mossman 1949). In both these animals the luteal tissue was derived from unruptured follicles in contrast to the picture in elk. Also in the rat and porcupine accessory corpora lutea develop at the same time as the primary corpora. This does not seem to be the case in elk as development of secondary corpora is not observed until about the time the embryo becomes macroscopic. Luteinization of unruptured follicles was occasionally observed in our material (Figure 3a). The gross appearance and size of this accessory luteal tissue is distinct from the secondary corpus and leaves little chance for confusion.

(c) Secondary corpora lutea. Following the postconception ovulation a progressive infiltration of luteal cells resulting in a secondary corpus was noted. Primary corpora lutea averaged 13 millimeters in size with a range of 10 to 18 millimeters. Secondary corpora lutea average seven millimeters and ranged from 5 to 10 millimeters, (Figure 3b).

When two fully formed corpora lutea were present in separate ovaries and pregnancy was advanced, it was rather difficult at times to distinguish the primary from the secondary. However, the rupture site was usually more distinct on the secondary corpus luteum. If both corpora occurred in the same ovary the effects of crowding were visible on the secondary corpus luteum, thus establishing the identity of the primary corpus.

When we observed two corpora lutea, they were present in the same ovary 55 per cent of the time. Gaab (1953) reported two corpora to be located in the same ovary only about eight per cent of the time. (Table 1). The growth of two corpora in the same ovary resulted in abnormal position of ovarian structures. Often the two corpora lutea were so closely apposed that detailed examination was required to



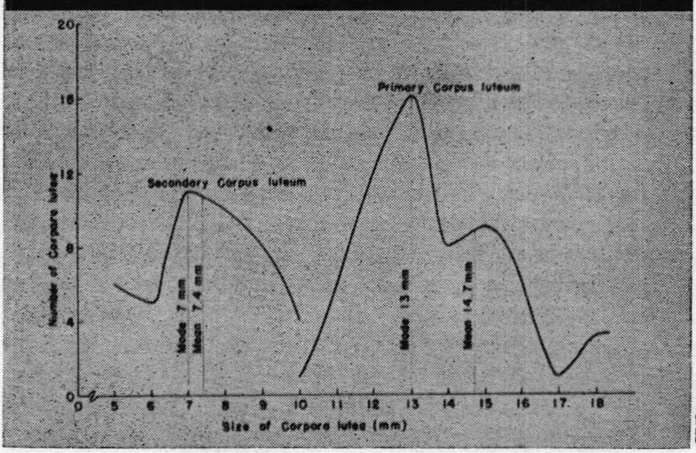


Figure 3a. Internal view of right and left ovary of nine year old elk killed May 15, 1951. Fetal calf weighed 38 pounds. Primary and secondary corpus lutea visible in right ovary. Accessory corpora lutea visible as rings of luteal tissue surrounding follicles in left ovary. Figure 3b. Frequency of size of primary and secondary corpora lutea.

establish autonomy. Because of this condition the second corpus could be easily overlooked. Crowding also tended to obscure the pigmented scar, left by degenerating corpora lutea of previous pregnancies.

ADDITIONAL OBSERVATIONS

In addition to the case of twinning preivously discussed, two pairs of ovaries were collected with two corpora lutea in each pair but with no evidence of embryonic tissue to indicate pregnancy. In both of these cases one corpus luteum had a decadent appearance and convoluted periphery. Histological examination showed that the luteal cells were necrotic. Numerous examples of pycknosis and karyolysis and in some instances complete breakdown of cells were observed. The other corpus luteum appeared normal and functional. It was assumed that these animals failed to conceive at the first estrus and had repeated one estrous cycle. It seems evident, from these data, that if the estrous cycle is repeated the corpus luteum of the first cycle may begin early necrosis but degeneration may not be complete by the time the second corpus is formed.

In contrast, regression of corpora lutea of pregnancy apparently is slower than the regression of corpora lutea of ovulation. Two apparently functional corpora lutea were found in the ovaries of two elk collected postpartum, indicating that both corpora persisted through term. Another elk collected about two weeks postpartum contained two corpora lutea, neither of which showed any degenerative changes. Two elk collected in July on the National Bison Range by Morris still contained luteal cells in the corpora lutea. Both these cows were suckling calves at the time they were killed.

Following parturition the primary and secondary corpora lutea regress and each forms a pigmented scar. The length of time that these scars persist is not known. However, scar tissue was visible up to the next breeding season in some of the ovaries examined. An example is seen in Figure 1a. Because of the relatively large area occupied by developing follicles the scar tissue is often displaced. Serial sections may be required to obtain a reliable count.

DISCUSSION

The formation of corpora lutea after conception has been observed in mammals other than elk. In the mare secondary corpus luteum formation is normal (Asdell, 1946), although the time of the formation of the second corpus luteum is later than that for elk. Secondary ovulation, secondary estrus, and even secondary conception with the survival of young from both matings has occurred in mink (Hansson 1947). Perry (1953) reports the formation of secondary corpora in elephants. Therefore, it is evident that postconception ovulation in elk is not unique among mammals.

To date the biological implications of this second ovulation are obscure. Elk with only one corpus luteum seem to be as successful in their reproductive efforts as those with two corpora lutea. An explanation of the value of the second ovulation cannot be given. However, the following may provide an explanation of the mechanism involved: since the second ovulation appears to occur before the embryo becomes firmly attached to the maternal blood supply it is possible that the placental hormones are required to suppress the secretion of gonadotropic hormones. If this attachment does not occur before the normal cylcic secretion of gonadotropins, the ovaries may be stimulated resulting in a postconception ovulation.

SUMMARY

An analysis of 289 elk ovaries indicated that 66 per cent of all the pregnant animals examined had two corpora lutea. The data also indicate that in some populations this figure may approach 90 per cent. Chronological collection of material suggested that the following sequence of events probably occurs in elk: (1) Development and maturation of one initial follicle; (2) ovulation of a single follicle and formation of a single primary corpus luteum; and (3) development and ovulation of one postconception follicle with formation of a secondary corpus luteum at approximately the time the embryo becomes macroscopic; (4) persistence of the corpora lutea throughout gestation.

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DISCUSSION

DR. E. L. CHEATUM [New York]: Is it possible to have any degree of certainty in determining the origin of the scar with respect to primary or secondary ovulation as a means of getting the actual history of reproduction of the previous year?

MR. HALAZON: Without having complete pen controlled experiments I would hesitate to say. However, I do know that from examining these ovaries we do have both scars and initially the primary scar is larger.

LARGE-SCALE DEAD DEER SURVEYS: METHODS, RESULTS AND MANAGEMENT IMPLICATIONS[1]

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Game Division, Michigan Department of Conservation, Lansing

The white-tailed deer has probably had more study than any other game species on the North American continent. As a result, much is known about its natural history. Probably enough is known that at least a reasonably efficient job of managing this natural resource could be done if people would accept the fact that this management job is a technical rather than a political matter.

Whether the game manager has or has not the opportunity to use this accumulated knowledge concerning the whitetail, the search for more facts should and does go on. It can be assumed that eventually the public will see the wisdom of placing the management of the deer herd in the hands of those who know the most about deer. And, parenthetically, let it be added that these would-be deer herd managers need to learn something about the other unknown in the equation—man himself. It seems that many of the states or provinces in which deer problems exist have underestimated the difficulty of convincing the public that there is a problem.

In any type of scientific game management it is essential to know the limiting factors on a game population and the relative importance of these limiting factors. The purpose of this paper is to discuss certain of the influences limiting the white-tailed deer herd in Michigan and how these influences have been evaluated with a somewhat different method than used in the past. The study was conducted in Michigan but certainly applications can be found in other states or provinces with similar conditions.

It is general knowledge among game technicians that the reproductive potential of the white-tailed deer under favorable environmental conditions is high. A normal fully adult doe under favorable range conditions will usually produce twins. Many of the two-year old does in their first breeding season will have twin fawns. In the southern half of the Lower Peninsula of Michigan a third of the fawns breed their first fall and produce a fawn when they are a year old the following spring. With this kind of reproductive possibilities why aren't we ten feet deep in deer? Obviously, something is happening to keep the whitetails within bounds and not inheriting the earth, just as some-

[1] A contribubtion in part from Pittman-Robertson Project W-63-R, Game Division, Michigan Department of Conservation.

thing does with the thousands and thousands of other animal species on the planet.

One of nature's oldest, most common and most efficient checks on animal populations is a diminishing food supply when an animal population begins to realize some of its reproductive potential. The whitetails have felt the effects of this check on their numbers in many parts of their range. One of the major effects of poor nutrition is the lowered reproductive rate of the does. Instead of an average of better than one-and-one-half fawns per doe, the rate may sink down to an average of a fawn per adult doe or even less under extreme conditions. The other more spectacular result of a food shortage is outright starvation. The burden of this falls principally on the fawns. In some winters, something approaching half or more of the fawn crop can be removed in parts of the deer range by the combination of inadequate food supplies and severe weather conditions.

Where else may we look for a check on deer populations? Right away, many will think of predation. Mountain lions, wolves, coyotes, bobcats and dogs do account for some losses which may be serious in small areas. In Michigan, where an expensive bounty system is in effect, some people are inclined to credit control of predation as important in preserving the deer herd. But, Michigan has relatively few large predators capable of taking adult deer consistently. The possible exception to this generalization that predation is unimportant in controlling deer numbers may be summer predation on fawns. However, we have no good evidence to support either side of this question.

From *in utero* counts of 1.5 to 1.8 embryos per doe in good deer range, we come to something near a ratio of 1 adult doe to about 1.2 fawns in the fall hunting season. Figures obtained during an any-deer season during 1952, 1953 and 1954 in Michigan showed a herd ratio of 5 does (including yearlings) to 4 fawns. Selection of the larger animal by hunters may be a biasing influence on this ratio. On the other hand, increased vulnerability of fawns compared to does may compensate in the opposite direction.

Under exceptional circumstances disease accounts for some losses although on a country-wide or a state-wide basis, it does not appear as yet to be a significant mortality factor. The late summers of 1949 and 1955 were memorable for considerable local losses in the southeastern section of the United States. In 1955, Michigan and New Jersey also experienced localized losses which on the basis of available evidence appear to be due to an infectious process probably viral in nature.

In the spring of 1955 a large-area "dead deer" survey was organized in Michigan. It was designed to give us better information on mortality factors affecting the herd from approximately the beginning of the deer hunting season (Nov. 15) to the end of the yarding season in the spring. On a practical basis this was a point where the snow had disappeared so that any carcasses could be more easily seen. The country covered by the sampling procedure was roughly the upper half of the Southern Peninsula of Michigan, or an area of approximately 18,000 square miles. There were two mortality factors that were of particular interest to us, *i.e.*, starvation losses and illegal shooting losses occurring during a bucks-only deer season. Of importance too, were losses due to unrecovered hunting season mortalities, predatory animals, disease, accidents, etc., although from general observations, we had reason to believe that the latter group would make up a smaller proportion of the total.

The winter of 1954-55 was of about average intensity so starvation losses were expected in the worst part of the deer range although the state herd had been reduced in 1952 by a kill of 160,000. Included in that year was a 3-day special any-deer season after the regular buck season in which 100,000 deer were taken in the upper part of the Southern Peninsula.

There was a special interest in the results in connection with losses of does and fawns during a regular bucks-only season. This was brought about by spot checks on two small areas the previous season in which the illegal kill was found to be relatively important. Questions were raised in our own organization as to the conclusions which might be mistakenly drawn regarding the size of this loss when applied to a large area of the state. It seemed necessary and desirable to obtain further information to clarify the situation.

There is what we believe to be a somewhat important influence in the apparent reluctance to recognize the wastage of does and fawns occurring during a bucks-only type of deer hunting season. Although having nothing but indirect evidence, we believe that some of the seeming unconcern officially over this wastage of game is due to a fear that the hunting public may blame the law enforcement officers for not preventing it. To anyone with any familiarity with the difficulties involved, it is, of course, recognized that the enforcement officer faces an utterly impossible task in preventing this type of game law violation. Doubling, tripling or quadrupling the numbers of enforcement officers would be likely to have little effect. However, the average sportsman is well enough sold on the value of game law enforcement to think that this would be a solution. Or, he might blame the enforcement officers for not doing their jobs efficiently. Either situation is undesirable.

We offer an example to illustrate the futility of normal operating enforcement procedure in preventing the shooting of does or fawns during a bucks-only season. Michigan has a 3,500-acre public hunting game ground in the northeastern Lower Peninsula, known as the Rifle River Area. There is only one road available for access and a checking station is maintained on the road at the entrance to the area. All hunters are checked in and out. Enforcement officers and other department personnel are in and out of the area frequently. Here, if anywhere one would expect hunters to be more careful in their identification of the target at which they were shooting. But, on this area in 1953, the hunters shot 38 does and fawns in taking 66 legal bucks. During 1954, in another area (Gladwin) of 8 square miles, a special effort was made to find out the size of the illegal kill. Three game biologists assisted occasionally by other department personnel patrolled this area almost continuously for the first week of the buck season. They succeeded in spotting 23 doe and fawn kills but could only account for 15 legal buck kills. A few additional bucks (estimated at 5) could have been taken out of the area, but in any case we believe that in this instance the illegal kill actually exceeded the legal kill.

The effects of illegal shooting at other times of the year than the hunting season are largely unknown. There seems to be no available method by which the extent of these losses to the deer herd can be measured. All that can be offered are isolated observations and opinions. Summarized, these point to a sizable loss in some localities.

This whole problem has received deserved attention in some other states, notably Wisconsin and Utah. Joseph Hickey[2] of Wisconsin has a compilation of the results of various studies on the subject in Wisconsin and elsewhere. He concludes that the illegal kill under a bucks-only law will average about half the legal kill.

METHODS

The sample unit used in this survey was an 80-acre plot laid out as a strip 88 yards wide following the outline of a rectangle one mile long and one-quarter mile wide (Figure 1). The plots were searched by four-man crews with each man presumably searching a strip 22 yards wide. Choice of this sampling unit was based on previous experience and the assumption that a strip would be somewhat more

[2] Personal communication; Nov. 21, 1955.

efficient than a rectangular plot. The one-chain spacing between men is believed to give fairly reliable coverage although it seems probable some dead deer were missed in heavy cover. Search crews were instructed to slow down and follow a zig-zag course (excepting the compass man) in the heavy cover. Some further errors of measurement may have occured due to accidental variation in spacing between men, and due to the necessity for depending on paced distances for plot dimensions.

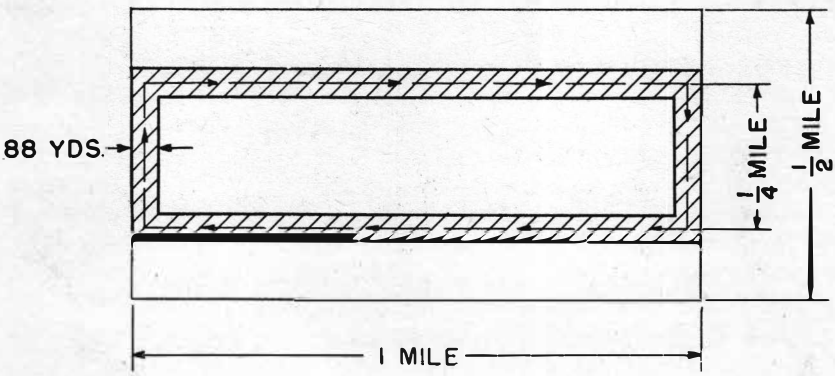


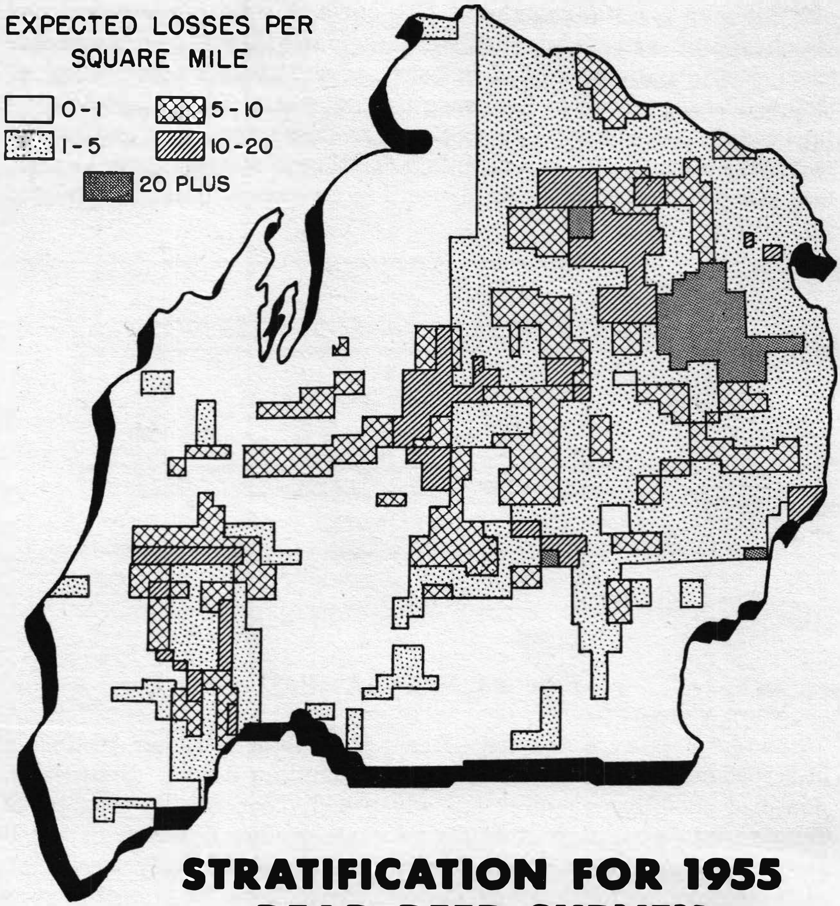
Figure 1. SAMPLE PLOT

Sample plots were distributed over the northern Lower Peninsula in accordance with a stratified random sampling design. Essentially, stratified sampling requires the advance division of the area to be sampled into a number of levels or strata having different expected numbers of dead deer. Sample plots are then randomly located in each stratum. In this survey the number of plots in a stratum was dependent on the area and expected variability of numbers of dead deer in the stratum.

Five levels of expected numbers of dead deer (strata) were used. District biologists and enforcement officers classified each half-section (320 acres) as belonging to one of the five levels. A generalized view of the stratification is shown in Figure 2.

A total of 114 sample plots were located at random in the five strata, and 113 of these plots were actually searched. One plot was completely flooded and portions of a few others were under water.

A biologist was assigned to each survey crew to examine any deer found. Usually the other crew members were enforcement and fire control officers. A field autopsy was conducted to determine the cause



STRATIFICATION FOR 1955
DEAD DEER SURVEY

Fig. 2

of death for each deer found. The autopsy usually consisted of a search for bullet wounds and examination of bone marrow as an indicator of starvation. Age and sex were recorded whenever possible.

RESULTS

Eighty-two dead deer were found on the survey plots resulting in an estimate of 32,500 dead deer for the area. Confidence limits at approximately the 95 per cent level of significance are 20,900 to 44,200 dead deer. Table 1 shows the estimates by stratum. The final estimates were generally lower than the expected values due, no doubt, to the fact that starvation losses were lighter than expected. Table 2 shows the classification of deer found in the survey by cause of death and the estimated totals for each category. Tables 3 and 4 show ages (to the nearest year) of deer found dead. Four deer could not be classified as to sex or age.

TABLE 1. AVERAGES AND TOTALS

Stratum	Expected dead deer per square mile	Average dead deer per plot	Average dead deer per square mile	Square miles in stratum	Total dead deer in stratum
I	20+	1.83	14.61	408.0	5,960
II	10-10	.62	4.97	1,048.0	5,210
III	5-10	.48	3.87	2,293.5	8,880
IV	1-5	.28	2.24	5,567.5	12,470
V	0-1	0	0	9,181.5	0
				14,498.5	32,520

TABLE 2. DISTRIBUTION OF DEAD DEER FOUND IN SURVEY

Stratum	Shot	Starved	Dog-Kill	Accident	Unknown	Total
I	3	30	..	1	8	42
II	11	4	:	:	3	18
III	6	..	3	1	5	15
IV	4	..	..	..	3	7
	24	34	3	2	19	82
Estimated Total Losses	14,280	5,420	1,770	740	10,310	32,520

TABLE 3. AGE OF MALE DEER FOUND DEAD

Age in Years	Shot	Starved	Dog Kill	Unknown	Total
1	6	9	2	4	21
2	5[1]	..	..	..	5
3	..	..	..	..	0
4	1	..	..	..	1
	12	9	2	4	27

[1] Four of these had "legal antlers.

TABLE 4. AGE OF FEMALE DEER FOUND DEAD

Years	Shot	Starved	Dog Kill	Accident	Unknown	Total
1	3	18	1	..	6	28
2	1	:	..	..	..	1
3	3	..	..	..	..	3
4	2	..	..	..	1	3
5	1	..	..	..	..	1
6	..	..	..	..	1	1
7	2	1	..	..	..	3
8	..	5	..	..	1	6
9	..	..	..	..	..	0
10	..	1	..	1	..	2
10+	1	..	..	..	2	3
	13	25	1	1	11	51

STATISTICAL DESIGN AND ANALYSIS

The statistical methods used in this survey are those described by Cochran (1953), Yates (1949) and others. Advance data were available for a previous survey which had been limited to areas of high starvation losses so that, in effect, we had design data for only the highest stratum. Estimation of standard deviations in the other strata was based on the assumption that stratum standard deviations would be proportional to the means (constant coefficient of variation). On this basis the sample design was as shown in Table 5, except that four plots were arbitrarily added in stratum V. The total sample size was selected to give two standard errors equal to about 25 per cent of the overall mean using allocation proportional to the products of the estimated stratum standard deviation and areas.

TABLE 5. DATA FOR SURVEY DESIGN

Stratum	Range of Estimated Dead Deer per Square Mile	Average Estimated Dead Deer per Plot	Area in Square Miles	Area as Proportion	Estimated Standard Deviation	Sample Allocation
I	20+	3.75	408	.0220	4.88	23
II	10-20	1.88	1,048	.0566	2.44	29
III	5-10	0.94	2,293.5	.1240	1.22	32
IV	1-5	0.31	5,567.5	.3010	0.40	25
V	0-1	0.01	9,181.5	.4964	0.01	1
			18,498.5	1.0000		110

Survey results as given in Table 6 indicate that the assumption of a constant coefficient of variation was probably not valid and that the strata having low mean numbers of dead deer were undersampled.

TABLE 6. SURVEY RESULTS

Stratum	Sample Size	Standard Deviation	Mean Dead Deer per Plot	Coefficient of Variation (%)	Component
I	23	2,146	1.826	118	.000097
II	29	1.082	0.621	174	.000129
III	31	0.724	0.484	150	.000260
IV	25	0.541	0.280	193	.001062
V	5	0.0	0.0	0	.0
	113				.001548

The over-all mean (weighted) is .2196 dead deer per plot and its standard error is equal to $(.001548)^{1/2}$, or two standard errors equal about 36 per cent of the mean.

Study of the distribution of dead deer per plot in the various strata suggests that distributions in the higher strata (I and II) were likely some "contagious" type—possibly the negative binomial, while those in the lower strata (III and IV) are closely approximated by Poisson distributions. This suggests that, in similar circumstances where a variance estimate is available for only the highest stratum, one might more nearly approximate "optimum" allocation by assuming the lower strata to have standard deviations about equal to the square roots of their means, rather than assuming a constant coefficient of variation as sometimes suggested (Yates, 1949, page 28; Hansen *et al.*, 1953, pages 215-219).

In effect, a systematic subsample was taken in the survey since the selection of sample areas was based on half-sections and only one-quarter (80 acres) of each sample half-section was searched.

Some notion of the efficiency of the sample design used can be obtained by estimating the number of plots needed for other methods of allocation (Cochran, 1953, page 99) to give the same standard error. Simple random sampling would require about 260 plots and "optimum" allocation with the observed stratum standard deviations about 90 plots as compared to the 113 plots actually used. One uncertainty in such comparisons is that no dead deer were found in the lowest stratum (V) while it seems quite likely that there were some dead deer in the area included in this stratum. Consequently the present data do not provide a variance estimate for the stratum, and on the assumption of a Poisson distribution in this stratum even a fairly low mean (.01 dead deer per plot) will have an important effect on allocation and variance estimates due to the large area (nearly 50 per cent of the total). One possible approach to this difficulty for future surveys is to make an intensive aerial search in the stratum (much of it is farmland) to estimate whether or not appreciable numbers of dead deer may be found here.

DISCUSSION OF METHODS

Man-power requirements for an extensive dead deer survey are necessarily large, requiring approximately 2 man-days per plot in this survey. Gains from stratification are considerable, requiring less than half as many plots in this case as simple random sampling and offering possibilities for further improvement. One important aspect of preparation for the survey descrbed here was the necessity for having agreement among field personnel as to the meaning of the stratum limits before preparing strata maps.

A further reduction in effort required in dead deer surveys might be obtained if one-man crews were used in such a manner that all deer seen could be included in the estimate rather than limiting observations to a fairly narrow strip on which supposedly all dead deer can be seen. Methods of this sort have been described and tested by Robinette *et al.*, (1954) but some uncertainty as to whether unbiased estimates would be obtained (Robinette *et al.*, 1956) precluded their use in this survey.

An additional possibility for reduction of effort in dead deer surveys may be in the use of combined aircraft and ground surveys using plots checked on the ground to provide correction factors for extensive aerial searches. An attempt to evaluate the possibilities of such a method was made in conjunction with the survey described here. The 23 sample areas in stratum I were searched by making three flights across each section (square mile) in which the sample plots were located. The flights were made with a Cessna "170" carrying two observers at about 500 feet of altitude and 70-80 m.p.h., airspeed. Forty-four dead deer were observed from the air as compared to 42 found on the ground plots. The area covered from the air was, no doubt, considerably larger than that of the ground plots (perhaps 3 or 4 times larger) but could not be accurately determined. (It should be noted that, if estimates are obtained by ratio methods, the area covered from the air does not need to be determined). Correlation between air and ground counts was so low that it does not seem feasible to use counts conducted as described above. However, it seems possible that much of the lack of correlation may be ascribed to the fact that the air search did not cover exactly the same plots as the ground search so further work is planned using ground plots marked with colored panels. Some general observations made during the course of this work suggest that carcasses of starved deer may be more readily seen from the air than those of deer shot the previous fall.

Difficulties in determining cause of death insofar as the illegal kill angle is concerned might be reduced by conducting a survey immediately after the hunting season. Such a survey was planned for the Northern Lower Peninsula after the 1955 season but could not be conducted due to snowfall. An additional complication may also be expected in that most conservation field personnel are subjected to a very heavy work load during the deer hunting season so that an extra week of intensive work immediately after the season might well result in personnel problems.

DISCUSSION OF RESULTS

Generally speaking, results of this survey may be expected to be conservative as estimates of losses to the deer herd. Basis for this supposition is the obvious likelihood that some dead deer on sample plots were not found in the survey and that some deer were illegally shot (poached) and removed.

Major difficulties in evaluating results of this survey are: (1) A considerable portion (7,300 square miles) of the area was included in a one-day any-deer season held after the regular 16-day buck season the previous fall so it was not possible to determine whether many does and fawns classified as shot were killed legally (crippling loss) or illegally, and (2) a considerable number of dead deer could not be classified as to cause of death. It seems likely that relatively few of the deer classified as dying from unknown causes were starved since deaths from starvation ordinarily occur in the spring so that most such carcasses are relatively fresh at the time of the survey. Also, bone marrow examination provides useful supplementary evidence as to nutritional status of deteriorated carcasses.

Most of the identified starvation loss occurred in Stratum I, which is largely composed of privately-owned hunting clubs. It seems reasonable to believe that hunters in these "club" areas are less likely to shoot indiscriminately during regular buck seasons because, (1) hunting pressures are low in the club areas and, (2) members have a proprietary concern about the deer herd on their lands. Also, many of the club members did not participate in the special seasons of 1952-1954. This situation led to the advance classification of the "club country" in the stratum of highest expected losses on the basis of expected high starvation losses. It also illustrates the point that high herd losses from illegal shooting may be beneficial from a biological standpoint when antlerless deer seasons are prohibited by law, since deer shot during the hunting season do not have an opportunity to damage the winter range before dying from starvation in the spring. It should be re-emphasized here that the winter of 1954-55 was not particularly severe in Michigan.

In considering the effects of starvation and illegal shooting as influences regulating the size of deer herds it is interesting to note the differential effects of these two mortality sources as shown in Tables 4 and 5. Starvation losses appear to be concentrated in the fawn and older doe (over 6 year) classes while shooting losses seem more uniformly distributed over the several age classes. Of course conditions leading to high starvation loss probably have other effects including lowered fawn production rates.

SUMMARY AND CONCLUSIONS

A sample survey was conducted during the spring of 1955 to estimate the overwinter loss of the deer herd in Michigan's Northern

Lower Peninsula. Results of the survey indicate that about 32,500 dead deer were present in the area during April of 1955 as compared to a legal harvest of about 41,000 deer the previous fall.

We believe that the extent of herd losses due to starvation, crippling and illegal doe and fawn shooting during regular buck seasons can be estimated within reasonable limits by this type of dead deer survey. The relative importance of seasonal losses due to factors such as predation, disease and accidents operating on a year-around basis can also be evaluated with a higher degree of accuracy than possible before.

Evidence from this survey and checks of various small areas indicates that the loss from illegal or accidental shooting of does and fawns in bucks-only hunting seasons may be much more important than generally admitted. Under average winter conditions, it may exceed starvation losses on severely overbrowsed deer range. It should be ranked along with lowered fawn production and starvation as a major limiting factor on a deer herd when bucks alone are legal targets.

Probably the only realistic approach to this problem lies in somehow converting such losses into a legal harvest, but as history shows, this is by no means a simple proposition in Michigan or several other states.

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TECHNICAL SESSIONS

Wednesday Morning—March 7

Chairman: HOWARD H. MICHAUD
Associate Professor, Department of Forestry, Purdue University, West Lafayette, Indiana

Discussion Leader: GEORGE W. WORLEY
Superintendent of Public Relations, State Conservation Commission, Des Moines, Iowa

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CONSERVATION EDUCATION

OFTEN OVERLOOKED FOUNDATIONS OF CONSERVATION EDUCATION

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Conservation at times seems to be vaporous stuff floating around with the clouds. In other places it seems well rooted. We ponder here some of the difficulties of anchoring it to reality.

Man, in his dreams, or in refuge from frustration, invokes an "open Sesame," rubs a magic lamp, recites labors of Hercules or Paul Bunyan, or searches for panaceas. Still dreaming, he explores the Arctic or Antarctic, tops unclimbed mountains, probes the mysteries of the atom and the universe, or studies the riddles of game species and recreational adventures which defy orderly management. He often does such things for fun or adventure—and likely dubs them "pure research."

Note how the same man in his games has a "home base." The explorer, temporarily defeated, retreats to base camp. The scientist, frustrated in fruitless quests, returns to scientific verities for guidance into fresh ventures. So the United States, as a young nation desiring a happy Union, and dreaming of life, liberty, and the pursuit of happiness, documented its principles in the Declaration of

Independence and built a strong foundation within the U. S. Constitution, to consult when seeking a safe course to follow.

It is fun to handle conservation as a kind of Aladdin's lamp. With enough polishing it promises happiness. Individual dreams conjure endless delightful phantasies of what conservation can mean and bring. But college teachers, too, are compelled to be realists. We are charged with training effective professional conservationists. We face need for dreaming enough to inspire young men to explore the remaining frontiers of science, and responsibility for interpreting the known world in a manner that makes sense. Young men need foundations. We have found many. We need more.

Much of professional conservation rests upon technique and policies. Young men learn techniques readily, be they tennis strokes, ski turns, wildlife censuses, or tourist studies. But policy involves so much history, legal and other human conflict, tradition, and philosophy that it seems nebulous to young men—unless reduced to terse, readable documents.

Men old in a profession have lived policy. They recall clearly when men, laws, and events evolved particular procedures or rules of thumb. Young men, unless shown sensible rules defining conservation objectives and procedures, tend to improvise policy. Other beginners in conservation enterprises tend to overlook wise decisions already made and projects already started. The result often is loss of effort, duplication of tasks already done, or serious oversight. The result may even be a determination to go ahead with some alluring project in disregard of decisions by scattered and obscure laws.

We who worry about achieving effective, concerted, conservation efforts, face three choices: The first is the centuries-old supine hope that some gifted and benevolent *führer* or strong man will lead us to Utopia. The Germans and Japanese, who were a docile people to their rulers, advanced early into admired conservation practices. But dictators bring catastrophe to their people as well as themselves. Many of us prefer the rolled-up sleeves and individual responsibility of democracy. Then we may deserve the individual rights it guarantees.

A second course is that of opportunism, in which individuals get away with what they can. Men who endorse opportunism say that democracy is too slow for efficiency. They claim they can navigate well enough "by the seat of their pants." They prefer strong men to laws. But opportunism has led to the very abuses which require conservation. Witness how we govern card games according to Hoyle, football games by a new rule book each year, and hunting and fishing by annual regulations, just to prevent unbearable opportunism. Great Americans like Chief Justice John Marshall and Theodore Roosevelt often have reminded us that ours is a "government of laws, and not men."

The third choice is the difficult task of evolving clear-cut laws and written policies, and professional men who will heed them, to guide our overlapping conservation efforts. The obstacles are almost insuperable. They include lethargy, legal precedent, vested interests, and attitudes we call just plain cussedness.

The foundation of our laws, the Constitution of the United States, is not the formidable document most citizens fear it is. It can be read, and enjoyed, by anyone of reasonable intelligence in one sitting. After reading it, we still honor our Supreme Court, which has the task of interpreting it, but discover that theirs is an enjoyable, rather than a monstrous labor. We have found that when the brief, eloquent preamble is excerpted along with the few statements governing our land laws and use, the foundations of most of our conservation laws are quickly recognized. We have introduced these excerpts into a booklet about wildlife conservation recently written in our part of the West for people of high school level of understanding, and into the news letters of rod and gun clubs. Now we wonder why we ever considered them formidable. Our students, once initiated, have in many cases read the entire Constitution.

Consider the manual of the U. S. Forest Service, which it has generously and intelligently maintained in forestry school and other libraries throughout its history. When a beginner in conservation beholds today's voluminous manual, h despairs at discovering within it the laws which founded our national forests and the Forest Service. But the brief legal statement of 1891 providing for establishing forests, the law of 1897 providing for their administration, and the law of 1905 joining the forests with the Forest Service, are collected at the beginning of the manual. Excerpted to accent pertinent provisions, they become intelligible and are an effective, time-saving, teaching aid in these crowded academic days.

The Forest Service had a particularly happy beginning. It was the first of several conservation bureaus to bear the idealistic name of Service. In addition, an interested, well-informed, and helpful Secretary of Agriculture, "Tama Jim" Wilson, took time to write a policy-defining letter to the Chief of the then new Forest Service. That letter read in part:

> "In the administration of the forest reserves it must be clearly borne in mind that all land is to be devoted to the most productive

use for the permanent good of the whole people and not for the temporary benefit of individuals or companies . . .

" . . . Where conflicting interests must be reconciled, the question will always be decided from the standpoint of the greatest good of the greatest number in the long run."

The National Park Service has even more fortunate founding laws. The Act of 1872 establishing Yellowstone National Park is simply stated. It covers less than a page. It eloquently set aside Yellowstone

" . . . as a public park or pleasuring ground for the benefit and enjoyment of the people . . . for the preservation, from injury or spoilation, of all timber, mineral deposits, natural curiosities, or wonders within said park, and their retention in their natural condition . . . [and] against the wanton destruction of the fish and game . . . and against their capture or destruction for the purposes of merchandise or profit."

The Antiquities Act of 1906, which provided for the creation of national monuments, was also a simple, readable, eloquent document. It covers less than a page of typewritten text. It has protected many natural, historic, and prehistoric wonders from vandalism. It will be incidentally honored this year when the first unit of our frugal and intelligent system of national monuments, Devil's Tower in Wyoming, will be commemorated in its 50th year.

The Act to Establish a National Park Service, in 1916, can be crowded upon one page. It simply states the work of the Park Service, as well as its over-all purpose:

" . . . which purpose is to conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Again a highly principled and intelligent Secretary of a federal department wrote a remarkable document defining the policies of a new conservation service. The letter from Franklin K. Lane, Secretary of the U. S. Department of the Interior, to Stephen T. Mather, Director of the National Park Service, May 13, 1918, long has been a guiding instrument.

Incidentally, one of the most effective measures in defining conservation objectives, consists of having someone in high authority face conservation issues involved and document them for all to read. We credit Secretaries Wilson and Lane with having written their letters from sheer love of their work, perhaps with some solicitation from the able first leaders of the Forest and Park Services. But simple policy definitions continue to be one of our finest conservation guides, from Magna Charta to this day.

The remarkable documents which guide the National Park Service probably owe much of their simplicity to the newness of the national park and monument venture amid the land uses of the world. The Park Service probably owes much of its stability and accomplishment, despite difficulties in defining and defending anything as abstract as a worthwhile outdoor experience, to the splendor of its guiding documents. Mission 66, which the Park Service now composes for its 50th anniversary in 1966, is an extension of such documentation.

This nation fortunately has found splendid leaders in times of great need. The first directors or chiefs of the Bureau of Biological Survey, Bureau of Fisheries, Bureau of Reclamation, Forest Service, National Park Service, Fish and Wildlife Service, and Soil Conservation Service and many of their successors continued this pattern. To their able leadership we owe much of our conservation progress. Unfortunately many of the agencies have not been blessed by clear-cut founding documents or defining policy statements. Lacking these, conservation activities and organizations have been threatened or even destroyed by lack of understanding.

A recent example of jeopardized conservation work was that of the Cooperative Wildlife Research Units. A survey team's report (1954) scrutinized Fish & Wildlife Service functions. These have evolved by acceptance of changing wildlife emphases and the passage of various treaties and laws, but apparently never have been broadly defined by simple documents or policy statements. The survey report stated:

> "The program of the Cooperative Wildlife Research Units appears to need reappraisal. Its original intent was described as providing a reservoir of trained manpower to fill the personnel needs of the Service. The scope of the program now considerably exceeds this definition, especially in view of the forecast limited hiring needs.
>
> "We recommend that Cooperative Wildlife Research Units be continued only where their projects and studies can be used to implement or replace studies and investigations which would otherwise necessarily have to be carried on within the Service."

Immediately those who favor the Units had to spring to their defense. There was no single, simple law establishing and sanctioning them and defining their purposes. Had there been, this emergency probably could not have developed.

Fortunately it is possible to define an enterprise by a law passed many years after some practice has crept into existence under vague provisions of previous legislation. Examples include the 1915 act under which the Forest Service was authorized to lease home sites, and the 1920 and 1935 acts under the Park Service was specifically authorized to accept patented lands for national park purposes. In both cases the practices had been followed for years.

One of the greatest needs today is legal recognition of recreation and wildlife in the arid West wherein demagogues, irrigationists, and engineers have strangulated or left to chance the future of wildlife and recreation dependent upon public waters. The recent Echo Park dispute was won by force of votes. The same conservation forces may soon be able to modify western "prior appropriation" water laws to include recognition of all conservation values.

One peculiarity of natural resource management differs markedly from legal trends. Foresters and other resource managers provide in their management plans for periodic revision to meet changing markets and growing knowledge. Laws often assume that conditions never will change. However, laws governing huge estates willed for purposes which no longer exist, have been modified to serve the spirit of the gifts after the original need had vanished. Western prior appropriation laws and original Echo Park water-use legislation were established for land and water-use conditions which since have changed. Need for periodic revision of laws governing natural resources must be recognized and desired changes made without endangering over-all objectives.

Perfecting our conservation laws and policy statements will be an arduous, never ending task. Some will say, "let sleeping dogs lie," only to be later caught by need for legal stability. Some will propose legal and policy statements burdened with minute details which hamper or prohibit administrative flexibility and improvement. The lofty ideals expressed within the Declaration of Independence, in the preamble to the Constitution, and in other admirable examples already cited should serve as patterns for reasonable generalities which do not obscure worthy objectives, and which permit freedom of action essential to good management.

If we can attain a framework of laws and reasoned policies to guide our conservation activities and education, we can train better professional men and will have fewer ignorant citizens leading us astray with unguided whims.

Conventions between nations and conferences between conservation agencies dealing with natural resources lead to excellent definitions of conservation objectives. Examples are the conventions between the United States, Great Britain, and the United Mexican States for the protection of migratory birds and mammals. Cooperative agreements between the Forest and Park Services for forest fire suppression, and between the Forest Service and the Fish and Wildlife Service for cooperative wildlife work are similar. Two separate agencies or nations cannot agree to cooperate without a clear determination of objectives. There can be no taking things for granted in the manner of a single agency or profession going along by itself. Broadened viewpoints result from all conferences, including this one.

In a mature nation that probably has surpassed the dreams of its founders, founding laws tend to become overlooked as something very important. And in the relatively new professions conserving wildlands and wildlife, many people still overlook need for public servants who possess professional knowledge and standards. Two decades ago Connery (1935) stated that "A highly intelligent individual is likely to allow his attention to wander off upon other problems." He advocated game wardens who, frankly, weren't very bright. But we now realize that local conservationists—rangers, wildlife conservation officers, and wardens—must be more than a kind of policemen. They can be more effective—or damaging—in conservation education as they work with local people, groups, and the press than a few experts in high places wondering why the populace doesn't think of and respect conservation disciplines as it should.

The Forest Service took leadership in this trend. Years ago it hired local cowboys and loggers to serve as rangers, and a few professionally trained men to handle technical details. Today it hires professional men only and starts most of them as rangers, learning to get along with local communities. But though important, to get along with and to be pleasant to local people and visitors no longer is sufficient. Conservation officers of all kinds must deserve respect if the conservation they represent and serve is to be respected.

Do not mistake our intent. As college teachers we do not demand that all conservation employees be college graduates. But we do believe that, whether self-taught or schooled on campuses, adequate training should give all of our conservation workers the attitudes of professional men, rather than opportunists working the present employment for all of the loot it will yield.

According to Blauch (1952) professional standards are those in which—

a. success is measured more by service and achievement in handling conservation challenges than by position and possessions.

b. the individual joins with others into associations organized to improve the "quality of their service" rather than to demand more remuneration.
c. the training is intellectual as well as practical in character, and marks the professional man as one with real perception and knowledge in addition to whatever practical crafts he may possess.
d. the professional man sees the place of his field in relation to others.

The details of professional learning, apprenticeship, and training are not equally matured in all conservation disciplines. The fields of wildlife and wildland recreation conservation which we represent, and into which we both gravitated from the older profession of forestry, are particularly immature. Textbooks are lacking for many phases of the work. Curricula differ greatly from one school to another. Schools are not accredited in the manner governing the older professions. Few definite plans exist for recruiting future professional employees. Employment openings are seldom synchronized with the traditional and essential time practices of the college. Salaries range below those for the longer established professions. Love of work fortunately has been great enough to lure a fair number of able men, but great accomplishments are needed to give all conservation workers the professional standards and recognition they need.

We conclude that we need better founding laws or constituting documents describing the objectives of all conservation agencies and organizations. Simple and understandable statements of conservation policies readily available to all who would use them must supplement the founding laws. Public servants and citizens must be capable of interpreting conservation policies and needs. Then we will overlook few foundations of conservation education and will get along with an important job.

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DISCUSSION

MODERATOR WORLEY: Thank you, Dr. Steinhoff, and please convey our thanks to Dr. Wagar for calling our attention the importance of these fundamental objectives and the need for professional training.

DR. CHARLES DAMBACH [Ohio]: I very much appreciated this fine paper. I gather from the discussion that you must have done some research in this field, and I wonder if you have prepared for your own students the kind of thing that you presented to us today and if there is a prospect of that being made available in published form?

DR. STEINHOFF: Yes, much of this has been mimeographed in one- or two-page discussions. They are not all together in one place or even in one of the two majors Dr. Wagar and I take care of. However, we would like to provide you with that material, although it is scattered.

MODERATOR WORLEY: Dr. Steinhoff, you spoke of professional training, and I would like to ask, to what degree do you believe that college training is implied? In other words, is that the only source of this professional training? I know, of course, it isn't, but to what degree is it involved in the type of professional training that you suggest?

DR. STEINHOFF: Of course, we don't imply that it must be college training. We all know that, especially in a young field such as this, there are many men who have developed this field who have little or no college training, but they have educated themselves until they have certainly achieved professional status. However, I think we would all recognize that that isn't usually a very efficient way to do it and if schools have any reason at all for existing and if they are doing the job, they should certainly be able to produce professional men.

INTER-AGENCY COOPERATION—KEY TO CONSERVATION EDUCATION SUCCESS

J. J. SHOMON

Virginia Commission of Game and Inland Fisheries, Richmond

Conservation education has been receiving increasing attention in America as we have approached and passed the mid-century mark of an atomic era, and rightly so. At these North American Wildlife Conferences, conservation education has been treated as a sufficiently important topic in recent years to warrant an entire half-day technical session, a forward step for which the Wildlife Management Institute is to be highly commended.

During the course of these discussions much wholesome light has been shed on conservation education, its scope, function, mechanics, how to achieve it, all of which has been useful and profitable. One aspect of how to achieve *more and better conservation,* however, has not been dwelled upon too strongly. This is the matter of inter-agency cooperation in achieving certain conservation education ends.

I shall not go into any details of the importance or need of conservation education. These facts are well established. We here are sold on conservation and so need not waste precious time convincing ourselves. The problem that faces us is how are we going to convince others. How are we going to transfer *needs* to *wants* among the great and ever-increasing masses of citizenry whose only understanding of resource problems is a vague, impersonal idea or something found only in the dictionary or government bulletins.

It's a big problem, this matter of mass conservation education, and it taxes the minds of men to the utmost. Ways of achieving it in *some* measure are many. Some of these will be discussed here. Ways of achieving it *in full measure,* on the other hand, have yet to be discovered. Certainly I do not have these answers.

The only proof I have is that where some measure of conservation education success has been achieved, it has followed certain tried and proven patterns. The enterprise, to be realistic, for instance, must be a cooperative and coordinated effort. In this connection inter-agency mutual effort and understanding is paramount.

A good carpenter by himself can build a fairly good house but two good carpenters working hand in hand can build a better one. By the same token, two good carpenters and a good architect can build a still better house.

HALLMARKS OF AN EFFECTIVE PROGRAM

Looking at conservation education, what can we say are some of the hallmarks of an effective program? I can think of five. There are many more.

1) Foremost, perhaps, should be *a unified approach to resource use education.* As man is a product of his environment and represents the acme of synthesized existence of millions of years, it behooves him to comprehend the unity of all living things. The singleness of resource conservation is meaningless. The wise use of all life-supporting resources—soil, water, air, plants, animals, inorganic minerals, and man—must be treated collectively. A car does not run on one wheel. It achieves its purpose because it is a mechanically near-perfect instrument.

2) *Strong inter-agency collaboration.* Since conservation's chief problem lies in arousing public opinion through the educational process, the highest form of coordinated inter-group understanding is needed between groups, government and private, dedicated to conservation. That this is good and that we conservationists are *all* for it we agree. We like to feel that we're doing a good job with all groups and that all is apple pie. But upon closer self appraisal, *are we doing the job we should be doing?* Is there not room for improvement? Which brings to mind the story of the fertilizer corporation.

The vice president in charge of personnel was eulogizing the fine work of the staff of the company one day and heaping encomiums on the sales force. "Why . . . why we have the best salesmen in the business . . . we've got the best cooperation . . . the finest product. We just got it, that's all." Whereupon a young warehouseman in the audience piped up: "Yes, boss, I know, but tell me, *why in h'—* aren't we selling more fertilizer?"

3) *Leadership without domination.* In the orderly development of any forward looking program, whether social, economic, educational or political, it is *leadership* that is all important. In conservation, leadership toward the educational process must initially come from the conservationists. It must be genuine leadership without domination, and it should be with the understanding that lasting and final leadership must be taken over by competent educational leaders themselves. Promoting a better understanding of wise resource use should be one of the added goals of the profession of education.
4) *Cooperation at all levels of learning.* Conservation training should not be categorized. Rather it *should* be continuous exposure from kindergarten to college and beyond.
5) *Widespread participation by communities and groups.* A high degree of conservation education can be achieved when it is promoted on a community level and as a group effort. Examples are cooperative conservation councils, community projects and state-wide resource workshops, contests, and the like.

SOME EXAMPLES OF PROMISING STATE WORK

That progress is being made in long-range resource use education is evident everywhere. Many states, notably California, Michigan, New York, Colorado, Wisconsin, Texas and Tennessee, have made notable strides in the right direction. In Virginia several examples of promising inter-agency and inter-group effort are worthy of mention. These are singled out not because they represent the best that has been done but because they are most familiar to the speaker and have proven effective beyond doubt. The four in mind are the (1) Virginia Resource Use Education Council, (2) the state-wide Conservation Essay Contest, (3) The Virginia Plan, and (4) the Lynchburg Project. Each has been so eminently successful that at least a partial explanation is warranted.

Virginia Resource Use Educational Council.

Organized in 1952 this voluntary group of 22 conservationists and educators representing state colleges and every resource agency, state and federal, in the commonwealth supplies the leadership for a broad program of concerted conservation education at the state level. Domination by one group is avoided, duplication and overlapping of services and function is curtailed. Meeting twice a year in an atmosphere of friendly deliberation, the Council comes to grips with immediate and long-range problems. That it has served as a useful vehicle for coordinated effort and leadership is attested by its two major accomplishments in less than three years' time: the preparation and publication of a much needed useful booklet on resource conservation entitled *A Look at Virginia's Natural Resources* and the sponsorship of several summer workshops for the training of teachers in conservation.

The former is aimed primarily at the seventh grade teaching level but at the same time serves as a useful publication for all grades and teachers, and the general public, telling the story of the state's natural resources and their conservation between two covers. Simple in text, inexpensive, essentially visual in approach, it has been rated by educators as one of the most practical publications in this field ever put out for the schools.

The workshop effort on the other hand is aimed at breaking the bottleneck of teacher training. Here the Council has backed a strong teacher training program at each state college and teacher training school in the commonwealth. A three-way cooperative effort was worked out. The colleges furnish the administrative details, the resource agencies supply the instruction (soil, forests, water, wildlife, fisheries, and minerals are adequately treated), and industry and private organizations provide scholarship funds to make it possible for the teachers to attend. Three-week summer sessions take place, with morning periods spent indoors in expertly planned working sessions, and afternoons devoted to field trips. This first year of the program, industry and organizations have contributed over $2000 in scholarship money toward the teacher training program.

The State-wide Conservation Essay Contest.

Another highly successful conservation education effort in Virginia involving the schools is the annual conservation essay contest sponsored by the Commission of Game and Inland Fisheries and the Virginia Division of the Izaak Walton League of America. This cooperative endeavor has the full endorsement of the State Department of Education and the support of all resource agencies and conservation groups. In the nine consecutive years of the contest some 125,000 young people from grades 5 through 12 have participated in this worthy project and have to a greater or lesser degree been exposed to, if not indoctrinated in, the concepts of conservation. Today the project is an integral part of the conservation training activities in 350 schools of the state's 1,274 schools, and participation is growing yearly. Perhaps no other school conservation project in America has achieved the high degree of success at the state level that the Virginia contest has earned. Success has stemmed from three sources: *simplicity and consistency and practicality of the project, leadership from the sponsors, and wholehearted inter-agency and inter-group support and cooperation.*

The Virginia Plan.

In contrast to the first two projects aimed at the schools, the forest-game cooperative effort known as the *Virginia Plan* has been an outstanding illustration of county, state, and federal inter-agency cooperation on a master scale. Here on 1,500,000 acres of national forest land four forces have combined conservation efforts to achieve more wildlife and improved hunting and fishing and generally better conservation education conditions over a wide mountain area. A "model cooperative agreement" between the U. S. Forest Service and the Virginia Game Commission has allowed special $1.00 hunting and fishing stamp monies to be used for joint effort at game and fish improvement. Result: Virginia's once remnant wild turkey populations west of the Blue Ridge have been built up to enviable proportions, the deer herds have grown from less than 2,000 animals to 115,000; fishing and general hunting conditions have improved vastly; and, doubly important, the people of the area (some 500,000 in population) have been made considerably conservation minded. Now a model for other states to follow, the Virginia Plan is truly a paragon of wildlife conservation achievement.

The Lynchburg Project.

Lastly, one additional example might be given to show what can and is being done on a community level. This is the Lynchburg project of the Izaak Walton League wherein the local chapter took over a weather beaten, run-down, impoverished 165-acre tract of suburban land and turned it into a model conservation park. The result has been that the chapter has grown to be the largest in the nation, a ten-year fight for a $5,000,000 sewage disposal plant for the city was won by an overwhelming vote (margin was six to one) and Lynchburg, a city of 50,000 and its environs has become an exemplary conservation community. The point might be made, too, that housewives were sold on the sewage treatment bond issue by the conservationists *even though they knew their water bills would be increased immediately by 70 per cent.*

That Virginia does not have a monopoly on commendable examples of resource-use education, one needs only to scan the range of states. Certainly the work of the California Conservation Education Committee deserves special mention. So does the Colorado Conservation Education Council. The $50,000 expanding forestry instruction program in Georgia high schools, involving a hundred 10- to 15-acre school conservation demonstration areas and summer workshop training for vo-ag teachers shows the South is not asleep. Neither was our host state, Louisiana, when the Louisiana Wild Life and Fisheries Commission saw the wisdom of advancing $31,000 to the University Press for the publication of the very popular and much needed book, *Louisiana Birds.*

Finally, and in conclusion, it might be well to restate the parallelogram that man, in order to cooperate to a good purpose in conservation, must first learn *the importance of cooperating with nature.* He must restrain his ways and temper his demands and utilize his remaining life-supporting resources compatible with a continued civilization. The time for apathy is at an end. Recklessness, contempt, selfishness must be banished if public interest is to prevail. The answer lies not in reaching the moon or the stars, not even upon science or mathematics, for neither of these has yet proved to be a substitute for the elemental workings of nature, *but in the full understanding of the enduring processes of our own mother earth and the living things about us.*

EDUCATIONAL PROGRAMS OF NATIONAL ORGANIZATIONS

SETH L. MYERS

Secretary, Outdoor Writers Association of America, Sharon, Pennsylvania

It is my purpose here, to mention only what I believe to be needed improvements in conservation education programs. I do not choose to offer answers to questions, but rather, to remind you that some of the answers are long past due. I shall not single out for criticism any organization. I am solely concerned with better management of outdoor America.

When I learn of several organizations approaching the same job, with different tools, I am reminded of once coming across the scene of a battle between two splendid buck deer whose antlers were locked in death. Both had struggled for control of the herd and its habitat, but had lost everything.

There are 200 millions of humans on our continent, with vast amounts of land, water and other good things which must be managed wisely if we are to continue to exist as God intended for us as his people.

In the constant fight for good legislation to guide us in using this heritage, there is no room for conflict between the groups that are dedicated to it. However, from time to time, friction has been known to develop, which may have lessened our chances of success in our good fight for conservation. One needs only to compare reports and resolutions of the various conservation organizations, to see the cause of some of the set-backs, suffered in our attempts to promote the legislation we desire, both in Congress and State Legislatures.

I have sat in meetings where organizations were considering pending legislation, when questions from the floor, asking whether other organizations had been contacted to learn if they would follow similar channels, were answered with: "We don't care what others do—this is how we'll do it!" I question the wisdom of such attitude by any group, whether layman organization or professional agency. That is the reason for some lawmakers having told me that we conservationists don't know what we want. It is exactly what some of them desire for getting off the hook with some of their constituents. They are probably pleased when they can play one group against another. The records show that it has been done time after time.

I think that one of conservation's worst enemies has been the jockeying of organizations for recognition, and unless we are able to work together, we may expect more upsets.

I'm afraid that our conservation organizations are not greatly interested in each other's programs. It appears that they are concerned only with their own accomplishment. And yet, I'm sure that all of them know that there are many questions that need answers. For instance, after all of these conferences, why is our soil conservation program so controversial as to retard its development? Why is this precious topsoil permitted to continue its "march to the sea"?

Why does a farmer tell me that there are three ways to manage his land? One, recommended by his state agent; another by a federal agent, and the one which was handed down from his father and grandfather before him.

Why, when I approach the manager of an industry, about his mill polluting the river, does he look upstream, with a sneer on his face, and snort: "Aw Nuts! There's plenty of clean water where this came from . . . ."?

Why does one state pay bounty on red fox while the conservation director of another, says: "It's just like pouring good whiskey down a rat hole"? It is natural that different geographical areas will be confronted with different problems, even though they are dealing with similar species. But how does one explain to the average angler, such contrast in fish management as may be found at the Ohio-Pennsylvania state line? For example, let us consider Pymatuning Creek, which flows from Ohio into Pennsylvania. The liberalized fish law of Ohio permits the taking of any species, in unlimited numbers, at any time, from the stream. Downstream, a few feet distant, across the state line, where the strict fish law of Pennsylvania is enforced, anglers may be arrested for acts which are legal for Ohioans. Other contrasts in management of natural resources might include whitetail deer, strip-mining, brush sprays, insecticides, rotenone and other features which are looked upon differently in different states. The public is puzzled over such contrasts. They don't know that in many such cases, commission biologists know that the wrong approach has been forced on them by legislation which has been pushed through by self-appointed experts.

When I suggest that our conservation education program needs improvement, I'm referring to the actual "putting across of the authentic data," which is needed to overcome a constant flow of misinformation emanating from questionable sources. There are many forceful, self-appointed experts in conservation, who are expounding their home-spun theories to the public, with utter disregard for the findings of scientific research. As an example, there is an eager-beaver wildlife expert in my state, who recently, devoted his television program, showing how he believes that bobwhites can be educated to roost and feed on platforms five feet high, to prevent predators taking their toll of these ground nesting game birds.

We are also plagued with political experts who believe that because they are elected by a majority of the voters, it sets them up as experts on just about anything that comes before them. And, there are also, the grass roots type, who hunt or fish occasionally, and feel that this educates them as experts on the outdoors. They are usually loud-mouth fellows who can influence voting at meetings, which on occasion, is directly contrary to good conservation measures.

While we don't like the misinformation given out by these people, we wouldn't want to take away their rights to speak and write what they please. That would be more harmful to us as a people, than all of their drivel. They must be shown up by getting the correct information across to the people.

Another practice which causes confusion about wildlife management is the premature reporting of untried ideas, theories and resolutions. Upon reading or hearing such reports, some people mistake them as new laws or policies and pass them on as facts. Should the ideas prove to be unworkable, they cause severe, although undeserved, criticism.

It appears to me that it is largely our own fault that the public is not properly informed of conservation needs, with the result, that we do not have their support in our fight for better conservation laws.

In conclusion, I'd like to mention that the original suggestion for this paper carried the subject with the word "Integrating" in front, but when I saw the printed program, with the word deleted, I held to what might be termed, "misintegration," and in summing up my comments, it appears to me that if we are to have an integrated program worth while, it will have to come from all of the conservation organization leaders sitting down together for the express purpose of creating it from careful study and reliable research.

DISCUSSION

MODERATOR WORLEY: The paper previous to Mr. Myers' pointed out some good examples of coordination and cooperation between agencies, both state and national, and Mr. Myers has suggested that things do not always run that smoothly. Do we have any comments or suggestions anyone wishes to make?

MR. JOSEPH PENFOLD [Colorado]: I would like to ask Seth a question. He speaks of a population of eleven million and license buyers totalling one million in Pennsylvania, and the question of how to get to the other ten million. Referring to my own State of Colorado, we have a population of one and a half million, we have five hundred thousand license buyers out of which ten thousand belong to any kind of an organiaztion through which they might acquire some conservation education; so I am wondering what can we do to get to this group of people who should be specifically interested in conservation, because they want to hunt and fish, but how do we get to them?

MR. MYERS: That is a good question—and believe me, that is what we are trying to find out. When a Senator says to me, "We are not too much afraid of you fellows because you have less than two hundred thousand men in your state sportsman organization"—(Last year we had 187,930 members in the Pennsylvania Federation of Sportsmen's Clubs, out of more than a million license buyers, or less than 20 percent in round numbers); I am afraid of it! I am sure too, that other states are ashamed of the fact that they can't get more of their people in conservation. We are working towards getting at least thirty three and a third percent in, so that when Jim Duff asks: "Why don't you fellows get organized?" I can say, "We are one third organized and can do a better job." I appreciate the fact that Joe Penfold has a better chance out there, to do a good job,—it seems to me.

I discussed that with Art Carhart and some of the other fellows, Joe, and you are far ahead of us in conservation education, because of that small population. For example, last week, we had a mother bear with four cubs hibernating near my home, and one of the game officers appealed to me on Sunday; "For Heaven's sake, put out an appeal on your program to the people, to quit annoying that mother bear." Actually—they destroyed that bear family, and there will be a prosecution if we can bring it about. They are some of the other ten million people in my state that I am talking about—who don't give a hoot whether that bear raised those four cubs to maturity or not. They don't give a hoot if there are any trout in the streams or game in the fields. All that they want forests for is to build their homes, and all they care about topsoil is to provide food to fill their own selfish stomachs. They don't give a hoot about the natural resources, simply because we haven't reached them!

MODERATOR WORLEY: Does anyone else wish to comment on this question?

MR. OLDS [Ohio]: I would like to ask Mr. Myers if he has a TV program?

MR. MYERS: Radio.

MR. OLDS: What do you think of a public agency obtaining public service time for conducting its own TV or radio program as opposed to the type of program you conduct as a professional?

MR. MYERS: I don't believe I am qualified to answer that. However, Jack Van Coevering probably could answer that a lot better than I could.

MR. JACK VAN COEVERING [Detroit, Mich.]: There are two ways of looking at it. A state program as such, could not be sponsored in our state. In that way, it might arouse interest in the subject. The commercially-sponsored TV, like the one I have on film which is run on 22 stations in the country, is competitive in a way and, sometimes, a station says, "We have already got an outdoor program. We get it for free from the state. Why bother to sell yours?"

I think that if anybody like myself is willing to spend his own money developing the program, sometimes it is a little tough to find the state agency in competition for free. But, as I say, there are two ways of looking at that. It might be that the general program might be advanced by having a wider distribution because it is free. I don't feel that most state programs are any competition to the private program because they are pretty lousy anyway.

CONSERVATION EDUCATION ACTIVITIES OF THE YOUTH GROUPS OF OHIO

A. W. SHORT

Department of Natural Resources and Department of Education, Columbus, Ohio

How many adults know the facts underlying their own security? How deep in their hearts do they really love America? How complacent are certain organizations and individuals within our borders? Do they really know the problems, facts and objectives concerning our forests, rivers, lakes, soils, minerals and wildlife? Has the term conservation often been accepted as piecemeal as though it applied only to trees, fish and game or the beauties of nature?

Have the majority been taught that land, water, vegetation and wildlife are interdependent? Without these primary elements in natural balance we can have neither water, fish nor game, soil nor trees, labor nor capital, nor sustaining habitat for human beings or wildlife.

Scientists have deciphered the secret formulae of chemistry and physics, they know how to transmute sawlogs into silk, how to deaden pain, and lengthen the span of man's existence with products distilled from nature's laboratories, but has enough thought been given to the perpetuation of the source of the natural resources with which they perform their magic? Scientists and economists have devised formulae for wealth, labor has claimed to be its sole creator, few people realize that without natural resources there would have been no labor, wealth, or human existence. Can all our hope and planning for happiness be based on the false assumption that natural resources are inexhaustible? Crumbling ruins where ancient civilizations prospered are mute testimony that other races miscalculated their wealth and degenerated to low living standards. Some of our present day theorists, policy makers, administrators and economists refuse to face the job of long range planning and action that includes the safeguarding of our natural resources.

When millions need education concerning our natural resources and their relationship to happiness, what can be done? How many people have you heard say we must start with the youth? Unless conservation becomes a social attitude we will continue to deal in anaesthetics for our headaches, rather than cures. We need more and more constructive conservation leadership, thinking and action. Our churches, homes, and schools are the three keystones in the arch of civilization.

The Ohio cooperative extension program in wildlife management and conservation was established in 1951 and is supervised by Mr. Robert K. Davis. The purpose of this project is to carry on a program of wildlife conservation education in the farm land areas of Ohio through the Ohio Agricultural Extension Service. This program coordinates the efforts and unites the resources of the Agricultural Extension Service of the College of Agriculture, The Ohio State University, and the Wildlife Division of the Department of Natural Resources.

Four and one-half years experience with this project have resulted in the development of four major lines of work: conservation education in the 4-H program; farm pond management; farm wildlife management; farmer-hunter problems.

Conservation Education in the 4-H program aims to provide the opportunity for our 72,000 Ohio 4-H members to have real life learning experiences in conservation. We work with camping programs and individual projects.

Each year Mr. Davis hires, trains and supervises a staff of conservation counselors who provide full-time conservation leadership to each 4-H camp in the state. These counselors lead campers in cook outs, fishing trips, gully control, pine plantation improvement, trail building, field trips, craft work and other activities designed to create appreciation for the outdoors. Each year a state conservation education camp is hel for outstanding 4-H members.

The 4-H club project program includes projects in soils, forestry and wildlife. Mr. Davis is currently revising and adding to the wildlife projects to encourage more learning activity in this area. Mr. Davis devotes a major portion of his time to non-youth work in farm pond management, farm wildlife management, (both production and control) and farmer-hunter relations problems. The Division of Wildlife finances this project.

In 1951 the Division of Wildlife also initiated a memorandum of understanding with the Department of Education which provided for the services of a Supervisor of Conservation Education in the Division of Elementary and Secondary Schools. The position was filled on February 1, 1952 by Robert Finlay who had been serving the Cleveland (Ohio) Public Schools as conservation curriculum co-ordinator. The Ohio Division of Wildlife furnished salary and travel expenses, The Department of Education furnished office space, stenographic help and some educational materials as teaching aids. The intent of this agreement is to develop and maintain a sound program of conservation in the public schools and teacher training institutions. There are over 55,000 classroom teachers in Ohio and 48 colleges with teacher education programs.

It is humanly impossible for Mr. Finlay to secure a report from 55,000 classroom teachers concerning the conservation activities in classrooms and camps for hundreds of thousands of youngsters participating in his project. Is impossible for Mr. Davis to scure any comprehensive report annually from about 3400 volunteer 4-H club leaders concerning conservation activities carried on in cooperation with the county agricultural agents, as these leaders change many time from year to year. However, in Mr. Short's activities with the Vocational Agriculture teachers and Future Farmers he has the same Vocational Agriculture teachers and students to deal with in the classrooms 36 weeks each year for a period of four years in most instances. These Vocational Agriculture teachers also supervise the conservation activities along with other supervisory practices on the farms of the boys and about 100 of the teachers in the state annually attend the Future Farmer activities given the boys at the Future Farmers' Camp. Therefore, in giving an insight to the conservation activities carried out by the Future Farmers in Ohio, in a given year, there is a carry-over of these activities in the program of the youngsters Mr. Finlay and Mr. Davis deal with annually.

The state office works in an advisory capacity with the local systems. Ten county systems and five city or village districts asked for the service of the supervisor during the first year. These initial steps led to the development of local workshops for in-service teachers. Some programs reached all the teachers in the system, others were planned as leadership projects involving certain selected instructors and administrators. Several of these systems are now working on follow-up plans.

A few teacher-training schools have shown interest in various phases of conservation education and the five state universities now cooperate in conducting the annual three, or five week course at the Ohio Conservation Laboratory. The supervisor serves as a full-time staff member at the laboratory.

Our approach to the major problem of getting the subject matter into the curriculum has usually followed a three-step pattern. First, to discuss the idea with the school administrators involved, we have found they must be in accord with our plans if the program is to be effective. Secondly, the superintendent appoints a committee of administrators, teachers, and other interested members of the community to work with the supervisor in planning the workshop, institute or field day. Third to include in this program some provisions for follow-up and to provide, wherever possible, the machinery for promoting the activity.

The planning committee in most cases selects local conservation problems as the basis for the teacher-training program. These problems vary in detail, but generally fall into the broad fields of water, soils, woodland, wildlife or minerals depending upon the locality (rural, urban or suburban), principal source of income (agricultural or industrial), and the major element in these respective fields, *i.e.*, general farming, dairying or stripmining, clay products, general manufacturing, etc.

The supervisor assists in developing these plans by suggesting field trips to be taken, resource personnel to be contacted, audio-visual material available, and numerous other items. The supervisor helps develop the follow-up plan which we hope will result in the inclusion of conservation as a part of the school curriculum. Our efforts are directed at integrating and correlating conservation within the existing courses of study rather than adding another subject to the curriculum. There is a genuine interest in conservation on the part of many administrators, teachers, board members and patrons. These people are looking for state level assistance in developing local programs and we feel that we have contributed to an effective solution of many of their problems.

Another cooperative conservation education project in Ohio is the one involving the Ohio Division of Wildlife and The Department of

Education with Mr. A. W. Short as supervisor. The philosophy back of the reason why the 11,542 Future Farmers in Ohio can, and should have an active participation in forestry, soils, water and wildlife conservation is because it fits into regular class-room vocational agriculture teaching and supervised projects in farm crops, animal husbandry, farm economics and agricultural engineering. There is a carry-over of interests, abilities, skills, appreciation and attitudes between natural resources and vocational agriculture. The program is accepted and put into practice by the Vocational Agriculture teachers and Future Farmers in order to get the work done on individual farms in the various areas of conservation with a *minimum amount of confusion or duplication of effort.*

The 350 Vocational Agriculture departments and 11,542 Future Farmers in Ohio are encouraged to provide and carry out practices concerning forestry, soils and water conservation. This will help provide good hunting, fishing and recreation, provide future Rural Conservation Leadership, encourage support of program and policies of the Department of Natural Resources, the U. S. Soil Conservation Service, the Ohio Forestry Association and others interested in a broad program, will help promote cooperation, tolerance and good will between farmers, Future Farmers and city people.

Technical assistance is given all Vocational Agriculture instructors and 11,542 Future Farmers relative to conservation problems. Soils and Water Management farm records are judged to determine the winner of the annual Soils and Water Management Award. Terracing, grass cropping, establishing waterways and contour plowing are practices put into effect to protect the soil from wind and water erosion.

Assistance is given the Education Section of the Ohio Farm Bureau with conservation workshops for Farm Bureau Youth. Many contacts are made with the personnel of the Department of Natural Resources, Soil Conservation Service, Vocational Agriculture Supervisory Staff, and Teacher Training Staff in Agricultural Education at Ohio State University to take care of requests for technical assistance.

About 25 county conservation panel discussions are held annually. Technically trained conservation personnel appear on these panels. Audience participation results and interest created is carried into an action program back on the farms.

Vocational Agriculture Departments are given instructions concerning conservation programs and movies. Teachers, County Agricultural Agents and Vocational Agriculture teachers are encouraged to take students to "Field day" demonstrations in forestry, soils, water management and wildlife. Plans for a uniform Arbor Day program are sent all teachers. Forestry and Fire prevention talks and movies are given in many high schools.

Cooperation is given the Ohio Forestry Association concerning forest fires in a concerted effort in 29 heavily forested counties. "Summer Conservation Activity Suggestions" are prepared for all Vocational Agriculture teachers and Future Farmers. The three supervisors meet with the County Agricultural Agents and other committee members on the Governor's committee concerning the annual Tree Planting program.

Publicity is furnished many organizations and individuals, upon request, as to what the 11,542 Future Farmers had done in conservation during the past year, particularly in forestry, field and woodland border planting, water, soils and wildlife. Several Conservation Education articles are written annually for the Ohio Conservation bulletin, the Agricultural Education monthly magazine, the Ohio Future Farmer magazine, and several national and statewide circulation magazines pertaining to agriculture and conservation. The president of the Ohio Future Farmers appears annually as a speaker on conservation at the League of Ohio Sportsmen and Ohio Conservation Congress banquets.

Some of the Future Farmer activities at their own camp are: an extensive Conservation, Recreation and Leadership Training program for 1,000 Future Farmers and 100 Vocational Agriculture teachers given annually in four equal length (five day) periods in three consecutive weeks.

Back home, the Future Farmer Chapters enter definite competition involving 44 approved activities in forestry, soils, water and wildlife conservation. These chapter activities are judged and the top chapters are chosen to receive scholarships to the Annual Conservation, Recreation, Leadership Camp. The top chapters choose the boy or boys to attend camp—all boys attending camp are not on scholarships.

Through lectures, field trips, demonstrations and movies, Future Farmers learn soils judging, soils mapping and land use capabilities, studied at soil pits and on nearby farms. Later, the land judging contest in June at Ohio State University (by 337 teams in 1955 with three Future Farmers on each team) is one of the results of the interest in this camp activity. Other conservation activities studied in camp are: Forestry, water, game management, fish management, trapping, law enforcement, rules, regulations, baglimits, liberalized fishing and fishing techniques. Instruction is also given in how, when and where to fish, and for what species, baits and lines to use, laws, rules and regulations for boats and boating on Ohio's streams and lakes. Farmer-Sportsman relationships, public hunting areas, pollution problems, farm ponds, posted lands, safety in the handling of firearms, game birds and song birds, how to identify fish, responsibilities of the various divisions of the Department of Natural Resources, migratory birds, marshes and marsh animals, farm ponds, forest fires and their control, farm woodlot management. The campers ask questions and decide what they will do on their individual farms about conservation. Top notch qualified instructors are on hand annually to give conservation education instruction to all campers. These camp activities are also fundamentally carried out by Mr. Davis and Mr. Finlay in all of their camp endeavors throughout the State.

The three men, Mr. Finlay, Mr. Davis and Mr. Short work many times as a team, sometimes as individuals, in keeping informed on what is going on in the State. We three men work with: The Interagency state committee on Recreation, Camping & Outdoor Education; the Agriculture Conservation program committee; attend all quarterly meetings of the Ohio Wildlife Research Unit at Ohio State University in cooperation with the Ohio Division of Wildlife and The Federal Fish and Wildlife Service; attend regular monthly staff meetings of the Chiefs and Supervisors in the Division of Wildlife; attend joint relationship committee meetings between the Vocational Agriculture Supervisory Staff, the Agricultural Education Teacher Training staff and the Agricultural Extension staff of the Ohio State University; attend Annual Fish and Game, and Parks hearings; attend Staff meetings of the Administrative staff, the District Supervisory Staff of Vocational Agriculture and the Agricultural Education Training staff at Ohio State University; Personnel Committee meetings of the Division of Wildlife; attend at State, County and Local level Agriculture and Conservation meetings and annual dinners—also attend technical sessions of such organizations as: Ohio Division of forestry meetings, Ohio Forestry Association, State Soil Conservation Congress, Vocational Agriculture Teachers convention, Future Farmers of Ohio convention, Ohio Water Clinic, Ohio Outdoor Writers, Ohio Wildlife Management Association, Consolidation of Schools, Friends of The Land, Future Farmers' Camp Board, The Advisory Vocational Agriculture Teachers' committee to Mr. Short and Izaak Walton League conventions and banquets.

Meeting with the above organizations and our own Conservation Employees gives us an insight as to the local problems, facts and objectives at The Grass Roots level. We are then ready to help them work out a program to fit the local situation needs, and then secure technical aid to put into practice a Forestry, Soils, Water, Wildlife and Recreational restoration and wise use program. The follow through and follow-up program generally moves through conservation personnel on County and District level.

The three supervisors are invited to speak to many organizations such as: Izaak Walton League meetings and banquets, Farmer-Sportsmens club meetings and banquets, Civic Clubs, Granges, Farmers' Club, Church groups, Parent Teachers Association meetings and banquets, Young Farmers club banquets (out of high school), Future Farmers—Parent and Son banquets, Boy Scouts, Girl Scouts, Garden Clubs, Grade Schools, high school assemblies, Farm Bureau Youth groups, Future Homemakers of America—Mother and Daughter banquets, Conservation panel audiences, Future Farmers' State Camp, 4-H Club County and State Camps, Future Homemakers' State Camp, Church group banquets, Vocational Agriculture Teachers' meetings (county and district), Soils Personnel and District Soils Supervisors (farmers) annual meeting, high school Vocational Guidance Days on requirements, education, etc. for Federal and State Conservation Employment, District-County Vocational Agriculture teacher Conservation Planning meetings, Future Farmers' Officer Training meetings, County League of Ohio Women Voters clubs, Buckeye Boys and Girls State annual convention, County Future Farmers and 4-H Club annual award banquets, Izaak Walton Club meetings, Teachers meetings, Teachers banquets, Grange meetings and banquets, School Administrators' luncheons, dinners and annual banquets.

In these speaking engagements, facts and objectives are intermingled with basic fundamental philosophies concerning wise use of natural resources and restoration of same for future generations and is of prime importance sometimes in getting our foot in the door. The request for help in getting a practical program follows later. Our main objective back of our endeavors is to help all of us remain a Strong and Free Nation and continue to contribute our share in the building of Goodwill and International Peace.

REPORT ON CONSERVATION ACTIVITIES OF FUTURE FARMER CHAPTERS IN OHIO COVERING THE PERIOD SEPTEMBER 1, 1951 TO SEPTEMBER 1, 1955

	1951-52	1952-53	1953-54	1954-55	Total for four
I. *Breakdown of Conservation Activities*					
A. *Soil Conservation*					
In how many of the following activities did the Chapter participate as a group?					

					years
a. Attended and/or participated in meetings, tours, plowing and terracing contests	917	954	626	631	3,128
b. How many members, individually, are working on Soil Conservation projects?	1,691	2,339	2,037	2,963	9,030
c. How many members, individually, were given some training in land judging?	1,161	1,852	2,520	10,036	15,569
d. How many (as a result of these projects) have:					
1. Used more grass in rotations on home farm?	1,447	1,557	1,544	1,416	5,964
2. Practiced contour cultivation, constructed diversion ditch, constructed terraces, used strip cropping, or developed a drainage system?	917	1,104	1,153	997	4,171
3. Protected stream banks from grazing and/or planted willows?	356	312	307	364	1,339
4. Farm ponds constructed	182	214	312	348	1,056
e.					
1. How many *members* live on farms which are developing a soil conservation district?	1,215	1,405	1,412		
2. This figure includes additional farms or acreage on owned, leased or rented farms which would include farms besides the home farm for the year *1955*				14,067	18,099
B. *Field and Woodland Border Plantings* (Not to be confused with tree planting for lumber production) How many planted? (This refers to plantings, not number of boys planting them):					
(1) Multiflora Rose	24 Miles	24 Miles	53 Miles	83 Miles	184 Miles
(2) Strips, borders, or spot plantings of pine or other evergreens	An Average of—200 Plantings per year				
C. *Forestry*					
a. Number of members participating in forestry improvement project programs	857	1,799	1,565	11,092	15,313
b. Acres in farm woodlots being protected against grazing	16,391	15,923	23,627	21,318	77,259
c. Acres of farm woodlots under a selective cutting	10,682	8,524	10,189	7,657	37,052
d. Number of trees planted for reforestation purposes (this figure includes all trees from the Division of Forestry, the Division of Wildlife, and all other sources)	360,133	928,676	586,264	379,259	2,254,332
e. Number of windbreaks planted	1,162	5,944	213	354	7,673
f. Number consulting a forester with regard to the management of woodlots	373	745	563	356	2,038

D.	*Wildlife*					
a.	Give number of:					
1.	Den trees saved	1,438	1,583	2,419	3,106	8,546
2.	Feeding stations built	531	432	628	648	2,239
3.	Food patches planted or rows of crops left standing as food for wildlife	354	320	357	341	1,372
	Acres in the Food Patches	419	264	532	365	1,580
4.	Natural marsh areas restored or protected for furbearers and other wildlife	223	186	96	96	601
5.	*Members* operating feeding stations during severe weather (Nov. 1 to May 1)	489	375	581	546	1,991
6.	Members protecting game birds, rabbits, etc., during normal mowing operations by using flushing bar, marking sites, etc.	599	391	844	640	2,474
	How many nests, homes, or rabbits do you think your Chapter saved?	3,924	519	5,204	3,324	12,971
7.	How many *members* left grassy fence rows to save nests and young?	895	1,025	2,536	1,375	5,831
8.	How many *members* left road berms and farm land hedges unmoved after July 1st?			1,602	1,375	2,977
9.	How many *members* planted wildlife food bearing shrubs?	168	241	1,610	663	2,682
10.	How many *members* trapped during trapping season?	1,832	1,906	1,741	1,848	7,327
11.	*Give total number* of furbearing animals trapped by members	19,893	18,166	16,011	15,029	69,099
12.	Brush piles constructed as homes for wildlife	1,582	992	1,044	1,863	5,481
13.	*Wildlife demonstration areas* visited?	152	201	205	338	896
14.	Assisted in rescuing fish from overflowed areas and in summer when streams and ponds were dry	961	1,101	1,534	186	3,782
15.	Saw an actual experimental test fish net lifted	247	418	1,422	675	2,762
16.	Number of wildlife law violations called to attention of proper authorities	86	81	269	187	623
E.	Number of programs on conservation prepared, sponsored, or given groups by Chapters	169	137	142	246	694
F.	Number of Chapter conservation exhibits displayed	121	87	169	156	533
G.	*Chapters* participating in poster contests on some phase of conservation	38	25	196	313	572
H.	*Chapters* sponsoring or attending a gun safety talk or demonstration	111	111	185	134	541

I.	*Chapters or members* reporting some cases of pollution	16	14	27	46	103
II.	Number of members carrying out some conservation activity..	8,214	4,024	6,887	10,903	30,028

There were *11,565* Future Farmers in Ohio in the School year 1954-55.

There were *345* Future Farmer Chapters in the state during the school year September 1, 1954 to September 1, 1955.

Number of chapters carrying out what would be considered a balanced Forestry, Soils, Water Management and Wildlife Conservation activities program..... 259

DISCUSSION

MODERATOR WORLEY: Thank you, Mr. Short, for an excellent review of the program that you have in Ohio. I am particularly envious of at least three individuals, you and two others, who have available almost full-time youth specialists, and I would appreciate knowing who pays them and what the arrangements, mechanical and financial, are?

MR. SHORT: Well, Mr. Worley, it works something like this. In Mr. Davis' case, he has an office and stenographic help in the Ohio Agricultural Extension Service in the College of Agriculture and the Division of Wildlife in the Department of Natural Resources, in other words, hunting and fishing licenses pay his salary and pay his travel expenses.

About four years ago, another program was set up and the Department of Education furnished office space and stenographic help in a downtown office and the Division of Wildlife again took on the burden of paying the man's salary and travel expenses.

You might be interested to know our Department of Natural Resources believes in this education picture and Ohio is one state in the Union that is willing to spend a little money until we get the thing going, hoping that the people with whom we spend the money will some day wake up to the fact that maybe they should be paying for it.

The Department of Wildlife underwrites the conservation laboratory to the tune of $3000. That is rental for the camp and a few other items. They believe that is a pretty good investment. The teacher goes back into the local communities to teach the youngsters. Many, many adult and youth groups use that camp each year.

In my case, I work with the Future Farmers and 350 vocational agriculture instructors and again, the Division of Wildlife comes forward and makes it possible for me to have a roof over my head and my family something to eat and they take care of my travel expense. Our office space and stenographic help is furnished by the Department of Education.

MODERATOR WORLEY: That is a fine working arrangement. I wish we had the same in Iowa. Perhaps some day we will.

MR. OLDS [Ohio]: I am sure Mr. Short will not resent this addition to his comments. Dr. Dambach was the Chief of the Department of Wildlife at the time this was established. The supervision of the three men concerned rests with the agency to whom they are assigned and is not retained within the authority of the Division of Wildlife, either the council or the chief. I think that is the point Dr. Dambach had in mind.

MR. SHORT: That is right, thank you.

MODERATOR WORLEY: That is as it should be; the responsibility is placed under the Department of Public Education.

CHAIRMAN MICHAUD: I am quite familiar with all the work they have been doing in Ohio and I know Bob Finlay; he is just as enthusiastic an individual as Mr. Short. I think that a very important part of our work in the field of conservation education is having the drive and enthusiasm for it.

MONTANA'S VENTURE IN WILDLIFE EXTENSION

J. W. SEVERY AND W. L. PENGELLY
Montana State University, Missoula, Montana

Montana's wildlife extension program grew out of the needs of sportsmen. They needed understanding of the manifold relationships which are involved in modern wildlife management. In the period following World War II, the Montana Fish and Game Commission was passing regulations and developing new policies which were not generally understood or supported. Consequently there was considerable opposition from individuals and the many groups interested in resource management. In group meetings, over the radio, and in some of the magazines they were told that times were changing and that new patterns of flexible management were necessary if wildlife populations were to be maintained. But they were not being told why.

What has been called the wildlife management forum was originally developed at the request of sportsmen from the Bitterroot Valley. They didn't call it that—they merely wanted to have some questions answered which did not seem to get solved on street corners or at typical sportsmen's meetings. They came to Montana State University in the fall of 1949 and asked the senior author, a former game commissioner, to meet with them and discuss these problems which seemed so vital to them. They were told that a certain basic information was fundamental as a background for intelligent problem solving. It was felt that they could arrive at decisions more rationally if they understood such fundamental relationships as the dependence of animals upon vegetation and the inter-relationships of climate, vegetation, soil and water.

Following this request, the program was given for two successive years at Hamilton. The ten-session series was developed and the techniques evolved during this time.

This program caught on eleswhere, slowly at first, but from its inception in 1949 until 1954, the course was given 14 times in widely separated communities by the senior author and cooperators from the state's educational institutions and several state and federal conservation agencies. The cooperators took the 10-session series in a special three-day training course held near Missoula in 1951 and repeated in 1952, and were invaluable in developing statewide interest as well as in sharing the volunteer lecture load. It soon became evident to some of the forward-looking sportsmen, lay and professional, that the forums were laying the base of understanding which they needed. A seven-point conservation education program was developed, submitted to the Montana Wildlife Federation and adopted at its annual meeting in January 1951. It was presented at the 16th North American Wildlife Conference by M. T. Messelt, a Great Falls sportsman, then chairman of the education committee of the state federation.

By 1954 requests for the forum far outnumbered the volunteer forum leaders. Consequently, the Montana Wildlife Federation petitioned the Montana Fish and Game Commission to allocate funds to Montana State College and to Montana State University in order to expand and stabilize these educational efforts with permanent full time personnel. The Commission allocated $7,500.00 each to the two educational units for the year 1954-55. The allocation was renewed for the year 1955-56 when it became obvious that the program had value, and was receiving strong support from people with a wide variety of interests. The junior author came to Montana State University in December 1954 as wildlife extension director and conducted forums during the winter of 1954-55 in five communities and in six more during the current winter. Eldon Smith was employed at Montana State College in the spring of 1955 and began his extension work in five eastern Montana communities in November 1955.

The wildlife forums are only given in a community at the request of a sportsmen's club or a civic organization. The sponsoring group handles publicity and arranges for a suitable meeting place. Each session consists of a more or less formal one-hour lecture, followed by at least an hour discussion period. Visual aids in the form of appropriate colored slides, big game browse plants, jaw collections and other demonstration materials are used to supplement the lectures. This has been helpful in getting the concepts across to lay groups and does much to attract and hold their interest. Guest speakers are occasionally invited to discuss their specialties.

In the discussion period following each lecture, questions with regard to management, particularly of local wildlife populations, continually arise. This is to be expected and desired. Consistently we attempt to help the audience consider all factors involved in a particular problem and encourage them to draw their own conclusions. We attempt to avoid taking sides on local problems. But we do take stands on policy and principles. Differences are usually ironed out as information is gained, and sportsmen, stockmen, farmers and managers of public lands usually agree upon action programs which are based upon the compromises which men of good will can make, when they have understanding and attempt problem solving upon a rational rather than an emotional basis.

Montana's wildlife extension program has two features which seem to contribute to its effectiveness:

(1) In the memorandum of understanding signed by representatives of the Montana Fish and Game Commisison, Montana State College and Montana State University, the two educational institutions are assigned the responsibility for selecting and supervising the personnel and shaping the content of the course.

The Fish and Game Department sends the allocated funds to the business manager at each institution and they are disbursed as wildlife extension funds. An accounting is given the Fish and Game Department annually, and monthly activity reports are submitted.

(2) The course content emphasizes the ecological relationships involved in population fluctuations, food chain concepts, and climate as it affects the development of vegetation and soil. Tolerance limits for certain characteristic animal populations, the retrogression of vegetation and soil with poor management, and the need for good watershed management are also treated.

In discussing the broader aspects of land management, it is pointed out that wildlife can be given priority in very few areas and that in most land economies, it is a secondary crop whose management must be interdigitated with the management practices which support the people of an area or community. Since the average sportsman usually owns little if any land capable of producing wildlife, emphasis is given to the concept that the amount and quality of wildlife in an area is determined to a high degree by the quality of land and water management practiced by the land manager. We believe the sportsman is and should be much concerned with securing high level management of both public and private lands. Constitutional law, federal and state legislation and court decisions are next considered. The implications of the delegated powers which all fish and game commissions have in varying degree are explained. The more important practices used in wildlife management are then taken up. The purpose of regulations, objectives of predator control, uses of parks, refuges and wilderness areas, effectiveness of fish and bird rearing and planting, and habitat improvement are discussed in subsequent sessions. Finally the last two sessions are devoted to the place of research and research methods in a management program. Emphasis is placed upon the profound changes which have been brought about by the application of research findings.

In our opinion, the wildlife extension program has one more important step to take. The program will not be meeting all needs until each community within which the forums have been given initiates an annual series of community-centered panel discussions built around their local wildlife and allied problems. Until this year, only Hamilton had initiated and developed such a follow-up program. At present, Kalispell is starting the same kind of community-centered activity. Sample panel topics include: big game management problems, statewide fish policy, wilderness preservation, and impact of hydroelectric and reclamation projects on fish and wildlife resources. At Hamilton, it also resulted in a well-chosen shelf of books in the public library, selected and purchased by the Ravalli County Sportsmen's Association for use by school students, sportsmen and other adults. Round-table meetings have been held for several years which have brought together farmers, ranchers, and sportsmen to consider problems of common interest. This program has not only contributed to better understanding but it has resulted in mutual agreement toward the solution of many local conservation problems. It is our feeling that this, like all other conservation efforts, must be regarded as a never-ending process. New information is coming out all the time and the community-centered program will help to keep the participants posted on advances in technical information and stimulates critical evaluation of local problems. Sportsmen are encouraged to subscribe to a wide variety of conservation literature, and reprints of technical and general interest articles are brought to their attention.

It is extremely difficult to evaluate the results of a program of this sort, particularly for those who have been closely associated with its development and presentation. Certainly the wildlife extension program can take only partial credit for the many changes for the better which have occurred in Montana during the past few years, not only in the attitudes toward wildlife problems, but toward all resource management problems. Conservation education is gradually improving in quality and quantity throughout our state school systems. Many youth organizations are carrying out conservation education programs, as are the various farm organizations, the soil conservation districts, the Montana Conservation Council, and many civic organizations. All vehicles of public information have been used. The radio, television and press have, in their better moments, made important contributions. No one organization, nor any one technique can claim that it has been responsible for all of the success attained in recent years.

For an impartial evaluation, the authors consulted with several conservation leaders who have been long acquainted with the Montana scene. They feel that the wildlife extension program strongly contributed to:

(1) improved relationships between organized sportsmen's groups and the Fish and Game Commission;

(2) closer cooperation between state and federal agencies;

(3) vastly improved relationships between the sportsmen and the land owner;

(4) improved organization of many sportsmen's groups and a much stronger state federation.

(5) appreciation within sportsmen's groups of the need for joint efforts to further wildlife aims and objectives;

(6) increased allocations for informational and educational activities within the Fish and Game Department as well as for other conservation education needs;

(7) better understanding by much of the press and radio, so that better management of lands, water and wildlife has been given increasingly strong support;

(8) a greater social and political consciousness to the end that an increasing number of sportsmen are taking positive stands on legislation at national, state and local levels;

(9) greater sympathy in the Montana legislature for sound wildlife legislation;

(10) an appreciation that technical wildlife matters are best handled by biologists, using the scientific approach to management.

This much is certain, the Montana Fish and Game Commission has been able to promote better management practices with the active support of the better informed sportsmen. Consistently, the soundest recommendations come from areas in which wildlife forums have been given. As evidence we need only cite that during the past season either sex deer hunting occurred in much of the state, two deer per license were legal in certain areas, and extended seasons and special license seasons occurred in critical areas. A vociferous minority opposed the liberality of some of these actions in Lincoln County, but all but one of the sportsmen who sat through the ten-session forum program at Libby last winter supported the actions of the Commission. The general acceptance throughout the state by the informed sportsmen of the drastic reduction in the North Yellowstone elk herd this winter was aided in part by their understanding of the need for better management practices. The Montana Wildlife Federation, at its annual meetings, is proposing and passing resolutions that indicate an awareness and maturity seldom equalled by lay groups.

The educational techniques described should work in any state.

Higher educational institutions recognize the need for extension programs, and would be glad to extend their services to the people in presenting such a program, were it not for financial limitations. Modern fish and game commissions have also shown a willingness to finance programs which expedite improved management practices.

The authors believe that these forums should not be given by the Fish and Game Department itself. It could, but long experience seems to indicate that agricultural-type extension is best carried out under the administration of a research and teaching institution. This gives the extension personnel contact with new findings, techniques and practices. Perhaps most important, however, is the fact that as a university or college staff member, the wildlife extensionist is largely freed from the accusation that he has to follow a "departmental line."

In Montana, the wildlife extensionists keep close liaison with the Fish and Game Department in order to know what its problems are, and how they are being met. But since each is actually a member of a university unit, neither have been accused by the informed sportsmen of having to promote department policy.

An effective conservation education program should develop sufficient social consciousness in the individual to cause him to accept his responsibilities, and it should keep him informed of new developments and their possible significance. One of the important end results of such a program is the active and informed participation of more citizens in the democratic solution of problems affecting the general welfare.

A functional democracy will require more rather than less education at the adult level. The forums give an unexcelled opportunity for a professional conservationist to interpret the voluminous data and literature pertaining to wildlife resources to a public that will be called upon more and more to make decisions affecting management.

Knowledge and legal authority are not enough to insure good resource management under our form of government. Our people are at their best, and their efforts bring forth the finest results, when they do things because they want to, not because they have been told to. The strong support given the wildlife extension program throughout Montana is perhaps due to the general feeling that it is objective, factual and has brought understanding which has increased willing participation by people of diverse backgrounds and interests in the solution of common problems.

Justin Leonard, research director of the Michigan Conservation Department, has stated that the greatest obstacles to effective conservation education are ignorance, apathy, and prejudice. In our extension work, we are attempting to replace them with understanding, cooperation and responsibility.

DISCUSSION

MODERATOR WORLEY: Thank you, Mr. Pengelly. I am certain you have something in Montana which is unique, and I know those of us concerned with conservation education have been sorry we couldn't do more about the adult education program. In my estimation this is a very effective one. We realize there are limitations in other states, perhaps because of the population involved, but it is certainly something that has been done and perhaps could be done to a greater or lesser degree in other states.

MR. GEORGE SELKE [Minnesota]: I would like to ask, what are the repercussions in the community? Do these people or the people in the communities in which you offer these courses turn to their local problems?

MR. PENGELLY: There has been a very excellent response to local problems. I mentioned the Libby-Kalispell program where they hunt bucks only. They were the main proponents of the buck law and they were packing Durward Allen's book under one arm and the California booklet under the other which said to save the herd, shoot the deer. We have had very few bad reactions from this.

Many of you are familiar with the town of Butte. You know, I have a special problem in Montana. We have had a group there that has not been receptive to anything that smacks of intellectualism. That is why I selected Butte. I thought to test the program I would start out with a good one. So far, we are still alive and I think the thing is working well. The best result I can see is an increasing awareness of the fact this is everybody's business and they are doing something for everybody.

MR. SELKE: Do you charge for enrolment?

MR. PENGELLY: No. That would be a good trick. The whole thing is financed by the Department. All my expenses are paid out of the budget. All the community has to do is provide a meeting place and I ask them to take care of the advertising and give them a brochure and news releases. They put it in the paper and provide the crowd and I provide the material.

MR. SELKE: Do they get a certificate or university credit or anything like that?

MR. PENGELLY: No, they don't. We can't always get the same group through the entire ten sessions, but it is surprising how many make them all.

MR. HOWARD ZAHNISER [Executive Secretary, Wilderness Society, Maryland]: A commendation of this program from a little different angle, I thought would be interesting to call to your attention.

The Council of the Wilderness Society last summer, in cooperation with the Forest Service staff, made a study of the Sellway-Bitterroot primitive area, and we had the privilege of having Mr. Pengelly accompany us. The way in which he related the wilderness problems in his groups with all the other problems, and then in helping us see the wilderness problem in terms of the way he has been telling it to them, was a remarkable demonstration to us. When Mr. Pengelly had these groups and lectured to us, we began to learn a lot and I wanted to add that commendation to this paper.

MR. GORDON FREDINE [National Park Service, Washington, D. C.]: Yellowstone National Park is a beneficiary this year of the good understanding that Mr. Pengelly and the Montana Program has been establishing in Montana. You are aware of course of the northern Yellowstone elk herd problem and the perennial job of trying to cut it back to the carrying capacity of the winter range. There has been in the past, a great deal of objection from people in Montana to that program, which has been partly responsible for the lag in getting the job done.

This year, I think, largely due to the efforts of the Montana program, the sportsman clubs in Montana came out in strong support of the National Park

Service's program to cut the herd back to within the carrying capacity of the range and I want to publicly give credit to that program for that fine support. [Applause]

MODERATOR WORLEY: Thank you, sir. There have been several testimonials to the effectiveness of your program and I, for one, intend to find out more about it.

MR. PENGELLY: I would like to add a comment. This program is a part of a double program. We can evangelize, but remember, when the Chautauqua lecturers and evangelists leave town there have to be a few preachers around to get them to church on Sunday.

What we have tried to do in Montana is stimulate interest. It is like playing a ball game by yourself. You can't bat and catch the ball and write the press releases on it yourself. So, we have tried to go along with the Federation people and program, which is to go into the towns and not make wildlife specialists out of all of them, because that is not what we want. But we arouse their interests so they will carry on in the programs next year with panel-type discussions. At Hannibal they were discussing ecology and a few years ago they didn't know what it meant. A typical meeting used to consist mostly of clobbering some federal agency. It is a treat to go into the communities that carried on the panel-type and open democratic discussions to get facts and eliminate opinions.

That is where we are failing in the program. We don't have enough personnel to carry on the second phase, which is community-sponsored and activated, and the only worth-while activity is that which springs from our desire. We, as Americans, are hard to force into anything. But, from the panel-type discussion, they want to learn things and the enthusiasm is rather contagious.

A METHOD OF TEACHING WATERFOWL IDENTIFICATION

DOUGLAS E. WADE

South Carolina Wildlife Resources Commission,

HAROLD M. STEELE

U. S. Fish and Wildlife Service, and

GORDON H. BROWN

South Carolina Wildlife Resources Department, Columbia, South Carolina

"Pulling together. . . ." This is what the South Carolina Wildlife Resources Commission and the U. S. Fish & Wildlife Service did. It brought about the development of a method of teaching waterfowl identification.

Interpreted narrowly, it would seem that the topic of waterfowl identification would not be too worthy of discussion in this international conference.

You can tab the name "mallard" on a dead duck or you can approach the problem *in its wholeness.* A much finer definition comes from consideration of not only the mallard's *taxonomy* but its *life history, ecology* and *applied ecology* (*management*). From this more "wholesome" concept seems to come a deeper appreciation of nature's unity. And, there seems to come a realization of why a major goal of conservation education is an understanding of the interdependencies of soil, water, plants, animals and human beings. Herein was some of the motivation that prompted a re-examination of identification instruction methods.

There are, however, in contrast to this broad approach, many examples of particularized identification of the moment that are most practicable. The conservation officer in the field or in the court must be able to name correctly dead ducks, geese and other birds found in the hunter's bag.

The validity of banding, fluoroscopy, periodical counts, hunters' kill records, nesting ground studies and estimates of population fluctuations on management or concentration areas depends upon correct identification.

It is our opinion that those intelligent hunters and bird watchers who know their birds are more apt to be "ethical" in their sport. It also seems that the "tyro" hunter may kill endangered or protected birds. He may unwittingly exceed bag limits.

With a large pool of competent volunteer observers to draw on, the coverage of continental or local counts and studies of waterfowl could be increased.

"Bagging" waterfowl on a check-list or on film helps to relieve gun-pressure. Such activities are a substitute for "killing the bird dead."

Conservation education gains when thoughtful wildlife officers, sportsmen and bird watchers act as instructors with local groups.

It is noticeable that those officers who have interest enough to master waterfowl identification also have other desirable attitudes and attributes. The confidence gained from being able to name waterfowl seems to affect other phases of an officer's work. Through the stimulation derived they are quite apt to go on to studies of life histories, ecology and management. This is a distinct gain for all the segments of a departmental program: enforcement, research, management, information, education and administration. The "preventive" angles of law enforcement receive more stress. Continental and regional aspects of waterfowl management and problems are better appreciated. Trained men are available for annual counts of waterfowl and for "educational" programs.

Identification is not an end. It is a valuable tool for all of us concerned with and responsible for conservation education. We must learn how to use it as a means of approaching the larger concepts.

In South Carolina two years ago in connection with the third annual game warden's clinic, a modest program was started on identification of waterfowl. A few mounted specimens, some 2 x 2-inch Kodachrome slides and 16 mm. films were used. Today we have more mounted specimens and slides, black and white photographs, additional footage of films and mounted wings.

"Identification Guides," including color prints of waterfowl and heads and wings, check-lists, written keys, brief life histories, ecology and description of management areas and refuges in the State, are planned.

Many of the wardens have purchased personal copies of Peterson's *A Field Guide to the Birds* and Kortright's *The Ducks, Geese and Swans of North America.* An annotated list of other publications on waterfowl has been mimeographed.

Copies of maps showing coverage during the post-season waterfowl count have been prepared by the U. S. Game Management Agent.

A display of bands and recovery maps should also help in rounding out the picture. We are working on these embellishments.

Still pictures and films are useful for identification, practice in counting (including "block" counting) and testing. They also point up problems of management and work underway. Such pictures and films have been made at waterfowl concentration areas by the Department's staff photographer. Cooperation from Federal refuge managers has been outstanding. They have helped build blinds and placed feed so as to get the ducks and geese closely into camera range.

We now know which slides are useful and how to use slides in combinations by using two or more projectors simultaneously. A new set of slides will show combinations of ducks (especially certain females) and plumage phases that have been confused in practice sessions. Duck pictures and paintings and live wild or captive birds are photographed or copied.

(There are many commercial sources of slides. Slides can be obtained for preview for possible purchase. Dr. Arthur A. Allen of Cornell University, Ithaca, New York, has many fine 35 mm. waterfowl slides for sale. Many other photographers have available slides. Recently the Fish and Wildlife Service enabled us to select for copies a series of slides made during some nesting ground studies in Canada.

Perhaps some arrangements might be devised under the auspices of the Wildlife Society so that instructional materials can be advertised and exchanged for preview and possible trade or purchase. Among all the institutions teaching wildlife management there is a richness of such instructional materials that could be put to work on a larger scale. Many museums have specimens they will loan or donate.)

Tape recorders have been used to obtain waterfowl sounds in the wild and by expert callers. We not only have made a start on this, but also have some talks and interviews with waterfowl specialists on tape.

All of these audio and visual aids have adaptability for radio, T-V, exhibits and talks before various groups. Adjustments can be made for age-levels predominant in an audience. (What concepts can be absorbed at various grade levels in schools is still very much a problem as far as wildlife conservation education is concerned.)

South Carolina is divided into five warden supervisory districts. Through the fine cooperation of wardens and Federal game management agents, we are now well on the way toward having six sets of mounted wings. Each district and the central office will eventually have a set of wings and slides.

These sets will be used during the summer at conservation education courses at the University of South Carolina and Clemson College, as well as loaned seasonally to organized youth camps.

The accumulation of sets of wings has been recommended to high school outdoor clubs, biology and vocational agriculture classes and 4-H, F.F.A. and Boy Scout groups. Wings could be donated by hunters or collected from hunters by conservation officers during the open seasons. Talks and films by conservation officers before these groups should help round out the picture of waterfowl management.

To "top-off" all of these introductory devices and methods, there should be field trips to waterfowl concentration areas with identification practice carried on under skilled leadership. It would seem desirable that conservation officers from sections of a state not containing many wintering waterfowl be given a chance to work a few days each winter in areas where they would see and handle many waterfowl. The more skilled men can be trained for counting from airplanes.

The "educational potentials" in the national and state wildlife refuges are worth exploiting. Witness the very remarkable increase of visitors to the National Wildlife Refuges during the past few years.

There are in South Carolina four national refuges and at least six state management areas, in addition to some fine state parks, that should have "identification" exhibits and interpretive guidehouses. (Guidehouse has a more "wholesome" connotation than "museum.")

There could also be guided trips to these wildlife areas for organized groups at stated times. Dwell on the implications of such trips, attended by proper publicity, during each National Wildlife Week!

Programs of this kind will require inter-agency and intra-organization planning and cooperation. Already, through the annual South Carolina Conservation Camp for high school youth, a start has been made on exploring certain potentials in one large National Wildlife Refuge. (This is a camp co-sponsored by Garden Clubs and Wildlife Federation Chapters and with a staff drawn from at least six agencies and organizations.)

In this "educational" use of wildlife areas, the National Parks Service interpretive program can furnish excellent leads. A study and re-evaluation of the National Parks Service interpretive program is now being made by Freeman Tilden.

The waterfowl instruction program, as developed in South Carolina, is now in its third year. Virginia and Tennessee have used Harold Steele and South Carolina materials in their conservation officer's in-training schools. The method received attention on the programs of the 1954 and the 1955 Southeast Wildlife Conferences.

In the instructional procedure in South Carolina the groups received at the start a written test based on viewing twenty slides. These slides showed the more common ducks and geese and "protected" birds sometimes shot by gunners. A re-run of the slides enabled each participant to score his own test. At this time also there were preliminary instructions on identification. Generally the scores on the test are quite low and thus an incentive (however desirable it might be) is provided for learning. *It is important to note that this sort of testing right at the start of a program obtains the immediate and active participation of the group.* From such a start the skilled instructor can more readily drive home the lesson in accordance with the goals set for the group. Initial group participation is sustained.

We have repeatedly noticed that when we put this program on with a sportsmen's club, the "organized" part of the presentation is invariably followed by a really "hot" open-discussion session on laws, loop-holes in laws, retriever dogs, duck-calling and management.

In working with conservation officers an early appeal is made (after the test) to their professional pride in knowing their stuff (in this case, waterfowl identification *in-the-hand*).

There is also accent on the fact that each officer is the *representative* of the agency. The public judges the agency through these officers.

Perhaps it is needless to add that this method used in teaching waterfowl identification is likewise applicable to other kinds of wildlife: fishes, birds of prey, shorebirds, upland game, mammals, snakes, and etc. To paraphrase a statement made by that famous Harvard entomologist, William Morton Wheeler: Stir in some "pabulum of ecology" when you start with the "freshmen."

In summary, we re-affirm that *any wild creature is most truly identified alive and in the wholeness of its natural environment.* A method of instruction should be so predicated that it sets off a chain-reaction that ends in the *enlargement of one's ecological conscience.* How to get at *the enlargement of the ecological conscience of groups* places the problem in a still greater perspective.

A HIGH SCHOOL CONSERVATION ASSEMBLY PROGRAM

DAVID LEE HANSELMAN

Department of Conservation, Cornell University, Ithaca, New York

With the increasing need for conservation education, we are recognizing the importance of starting this training with the youth. Although the activities of the 4-H Clubs, the Boy and Girl Scouts, and New York State Conservation Department camps do considerable training in the field of conservation, this can scarcely be considered adequate. The schools of New York State should also incorporate definite units of conservation study in the required curriculum. At present New York State includes virtually no practical conservation training in its public school curriculum, save in a few outstanding schools where especially interested teachers have forged ahead with programs of their own.

In an experimental effort to stimulate the teaching of conservation in the public schools and to supplement the social studies and science coverage, I devised a 45 minute conservation education assembly program. On June 7, 1955 my adviser, Dr. Gustav A. Swanson, sent letters offering the program to 110 New York State secondary or centralized schools falling within 125 miles driving distance of Cornell University. Many schools schedule their extra curricular assemblies for the next school year before summer vacation. Accordingly, it was gratifying to have 70 of the 110 schools request the program.

I was able to arrange ten hours of regular classes so that I was free to present the assembly program on Mondays, Wednesdays, and Fridays between September 23, 1955 and January 13, 1956. For this program I received an additional five hours of credit. It was possible to schedule and accommodate a total of 57 schools during the fall term between the above dates. During this time more than 33,000 public school students have seen the program, and in addition, it has been presented before groups of sportsmen, 4-H youth, Future Farmers of America, and Boy Scouts.

The New York State Conservation Council, Incorporated, a non-professional statewide conservation organization, made $500 available for program expenses and, with Cornell University, co-sponsored the series at no cost to the schools. The equipment was built during the summer in my home workshop. The slide projector and all supplies were obtained at discounted prices. Lettering and drawings were done by the art studio of the Department of Extension Teaching and Information at Cornell.

Expenses for the programs were as follows: Total equipment and supplies cost amounted to $416.47. A Revere #888 automatic slide projector, a Heath Kit 20 watt amplifier, lights and electrical supplies, lumber, hardware, and paint are included in this figure. With some of my own magic equipment and a few other odds and ends, I assembled the equipment at a minimum of expense. There was no labor expense involved, though well over one hundred hours of work went into the construction. Costs for meals and lodging during 45 days in the field, and for 5,706 miles of travel, amounted to $363.93. Three different state-owned cars from the College fleet were used successively. Two business coupes ran up a total of 3,665 miles at a cost of three and one-half cents a mile. A panel truck, while far more convenient, cost six cents a mile; it was driven a total of 2,041 miles. Mileage plus traveling expenses and equipment expenses totaled $780.40, or an average of about $12.38 per program (57 schools plus six other programs). Professional assemblies usually cost at least $35 and rates for many are as high as $50. It is to be remembered that I was not paid for presenting these programs; the $12.38 includes only net expenses per program.

Being not far removed from high school myself, I found it easy to plan the context of this program on the 'teen-age level! To hold the attention of the students I tried to be entertaining in style. For this reason and because graphic illustration helps to make concepts apparent, I devised rather elaborate audio-visual aids. In a 45 minute program it is impossible to teach the intricacies of conservation practices and management of soil and water, forests, and wildlife. The aim of the program was rather to develop an interest in this somewhat unfamiliar subject. It was hoped class discussions and other curricular activities would follow. The problem was to kindle this interest (Figure 1).

When enroute to do a program my vehicle was well loaded with

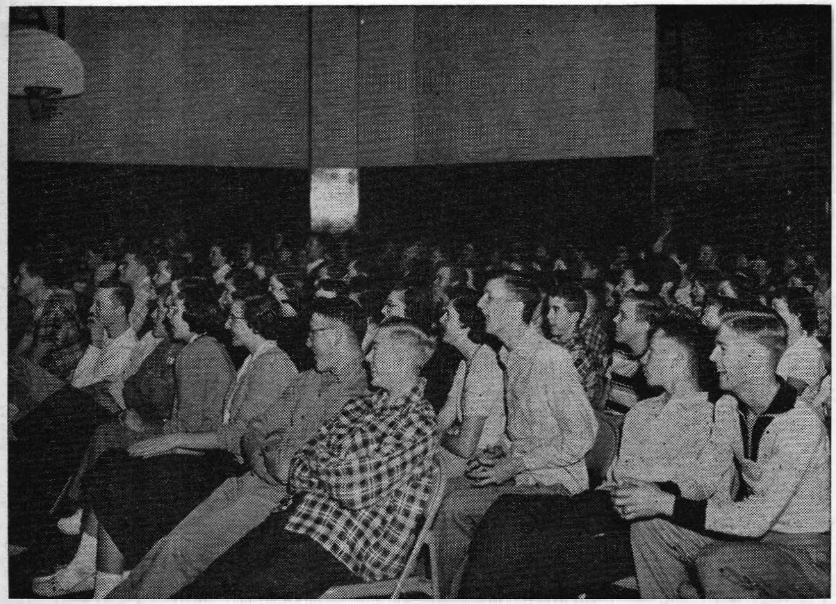

Fig. 1.
A bit of humor as magic is used to illustrate a point makes the program enjoyable as well as educational.

my many props. The program employs color slides which are used intermittently throughout the program. Two tape recordings are used; the first is an American Indian's comments on the white man's abuses of the natural resources. A second recording consists of selected excerpts from *The Symphony of The Birds,* a novel orchestration of bird voices produced by CBS in cooperation with Cornell University. The participating bird musicians were also shown in colored slides together with their individual songs to emphasize the cultural value of wildlife.

Two magnetic board illustrations (flannelgraph principle) are used to picture first a food chain and later to illustrate some management practices. A working demonstration shows the difference between run-off on a field plowed up and down hill compared to a slope plowed on the contour. A member of the International Brotherhood of Magicians, I illustrate several concepts by the use of prestidigitation. I tried to include enough humor in the presentation to keep audience enthusiasm high.

The program opens by introducing Chief Rockwell, present chief of the Oneida Indian tribe. By way of tape recording and color slides, the Chief tells of white man's abuses to our natural resources.

When the lights come on again, using the opening comments of the Chief as illustration, I continue to tell how we have abused many of our resources, and why conservation is important to everyone. "Just what does conservation mean? There are many definitions of the word, but the one I hope you'll always remember is just two words. Wise Use!" I point out that this means wise use of our natural resources, both kinds, the non-renewable and the renewable. The non-renewable resources are illustrated by slowly making a silk handkerchief vanish. "Like this handkerchief, once these resources are used, they are gone. If we are to use our non-renewable resources wisely, we should be as efficient as possible in mining, processing, and consumption." To illustrate the renewable resources one silk grows into two, and with proper management, or wise use, continues to grow into a string of three. The introduction concludes by stressing that "although conservation cannot become a profession with all of us, it should become a part of our lives. We all have an increasing responsibility for the way in which our natural resources are used."

The first major discussion centers around soil and water management. The management of a baseball team is compared to the management of soil on a farm. The analogy is quite evident; first you have to choose the player best suited for a particular position and then you have to coach, train, and manage him. Color slides illustrate choice of the right crop for the various land conditions. Then four management techniques—storing runoff water in marshes or farm ponds, diversion terracing, planting to anchor the soil, and contour plowing are illustrated. A demonstration further illustrates the principle of contour plowing (Figure 2).

The daily needs for water are elaborated; it takes 20 tons of water to make one pound of beef . . . 50 million gallons of water to run a large paper mill for one day . . . etc. This leads into a brief discussion of watersheds and their management. Magic is used to illustrate how forest cover will absorb the rainfall and return it gradually and over a longer period of time to the stream. A glass of water is poured into a red can which at first symbolizes a barren watershed. Tipping up the can results in all the water running out. This is compared to a watershed devoid of cover. Next, assuming the watershed to be protected by forest cover, the can is again filled and when it is inverted this time only a trickle of water flows out. Again the can is tipped up and again only a trickle of water flows out. This is continued until the glass is again full. The trickle illustrates how proper watershed cover sustains the flow of water to the stream. A brief discus-

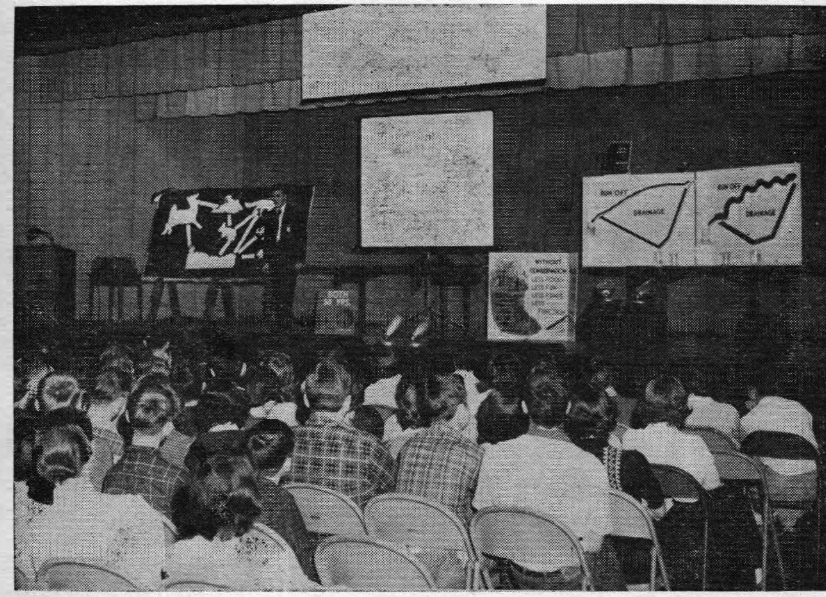

Fig. 2.

An attentive group listens to the discussion of a food chain, made clear by use of the magnetic board. Note other stage props. They are interest holders!

sion of pollution problems and their cure concludes soil and water management.

Forestry is next, with a brief history of its development in New York. How modern forestry practices can assure future lumber supplies and at the same time benefit wildlife is discussed. Thinning is demonstrated magically as three different colored small scarves change first to two larger scarves, and then to one much larger scarf. This illustrates that culling the inferior trees leaves the best crop trees more growing space and less competition.

Wildlife is the last major topic. Biological and esthetic values are discussed and a magnetic board story shows a food chain. After the interdependence of animals, plants, and soil and water are shown, the importance of adequate food and cover illustrated by the cutouts on the magnetic board. With cover the fox doesn't get the rabbit and consequently turns his attention to a mouse. The cover (a hedgerow) is removed and the rabbit ends up as a meal for the fox.

In summary, the benefits derived from good conservation are presented. The four values used for Food, Fun, Funds, and Function.

This presents a chance to bring in gun safety, respect of private and public lands, "litterbugging," and fire prevention.

During a sequence of slides, the background on the magnetic board is changed to a farm scene. With cutouts, conservation improvements are employed. Cattle are fenced from the woodlot; trees are planted on a barren slope, and a farm pond is constructed. In addition, a field is plowed on the contour and erosion along a stream bank is stopped by riprapping. A gullied field is planted with shrubs to benefit wildlife and to stop further erosion.

The program concludes by showing three panels depicting poor conservation. The middle panel is lettered, "Without conservation we have Less food, Less fun, Less funds and Less function." Drawings on the two outside panels illustrate this. When the panels are turned around the middle one this time reads, "Conservation means Wise Use for Food, Fun, Funds, and Function." The two outside panels again carry illustrations. The panels are folded into a triangular box, and magically from within, all sorts of items are produced. Vegetables, a quart of milk, a string of sausages, and an egg symbolizes farm produce, while a pack, a bird, a fish, and a bouquet of flowers suggest fun. Lumber, an electric light bulb, copper, and a newspaper tell of funds and functions.

The foregoing is only an outline of the context. Every speaker must find a style that suits him and pleases the audience. Because of this, anyone else's delivery of this same material would be quite different and therefore it would be valueless to go into greater detail of my presentation. A mention of a few of the techniques, however, may be of some benefit.

A podium is the control center (Figure 3). All lights for the various displays plug into the base of the podium. They are controlled by switches so that the speaker can control them as he wishes while on stage. The podium also houses an amplifier and one 12 inch speaker. The tape recorder, lapel microphone, and a second speaker also plug into the base. A small box housing green and red indicator lights, controlled from the podium, signals the stage crew to dim and to raise house and stage lights. A 90 foot, four-strand extension cord runs to the projector, where from the podium, it can be turned on and off, and slides changed automatically. When trouping from one school to another, and no two school stages are alike, it is of great value to have everything plug into a central box requiring but a single power input.

The use of a lapel microphone has distinct advantages. It is inobtrusive and assures being heard in the very last row. When you move

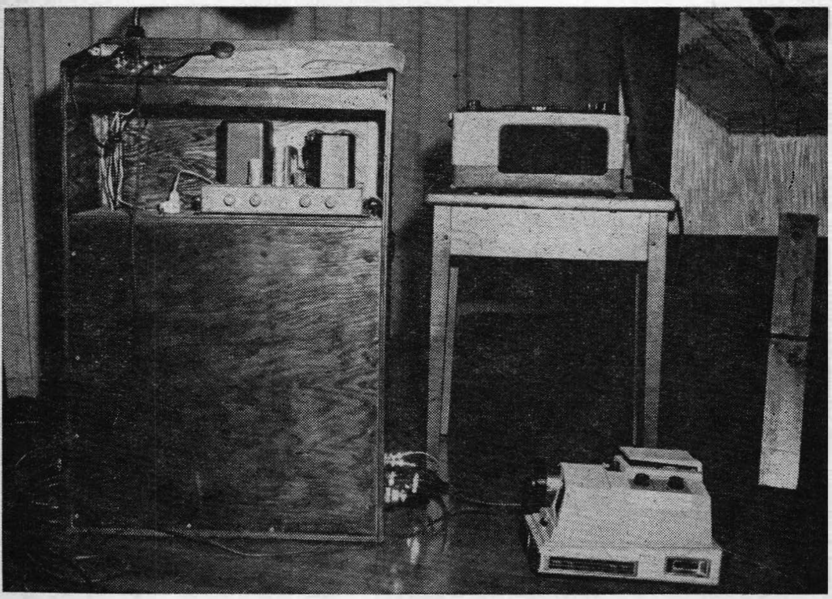

Fig. 3.

Back view of podium showing switches and lapel microphone on top and amplifier on shelf below. The enclosed part houses one 12 inch speaker. Note Webcor tape rcorder and Revere #888 automatic projector and cords plugging into podium.

from one demonstration to another, sometimes turning partially away from your audience, the microphone still carries your voice. I usually did two, and often three shows a day; without the mike, my voice would have been strained considerably.

Many of the smaller schools have very inadequate stage lighting. Consequently, portable lights aid clear vision and at the same time lend emphasis to the particular demonstration. I use swivel based reflectors and 300 watt reflector-flood lamps.

The magnetic board (see photo) consists of three panels which fold for easier carrying. When opened it measures 4 by 8 feet. Ordinary sheet metal was fastened to a wooden frame with Weldwood contact cement. The metal was thoroughly cleaned and coated with Galvite, a special Sherwin-Williams paint for metal surfaces. The art work and cutouts were made by the University art studio. Small Alnico magnets, obtainable from Magnex Inc., Denver 3, Colorado were fastened to the back of the cutouts. This means of illustration is becoming popular with many extension workers. Charts and maps can be fastened to a board and all sorts of cutouts may then be applied (Fig. 4).

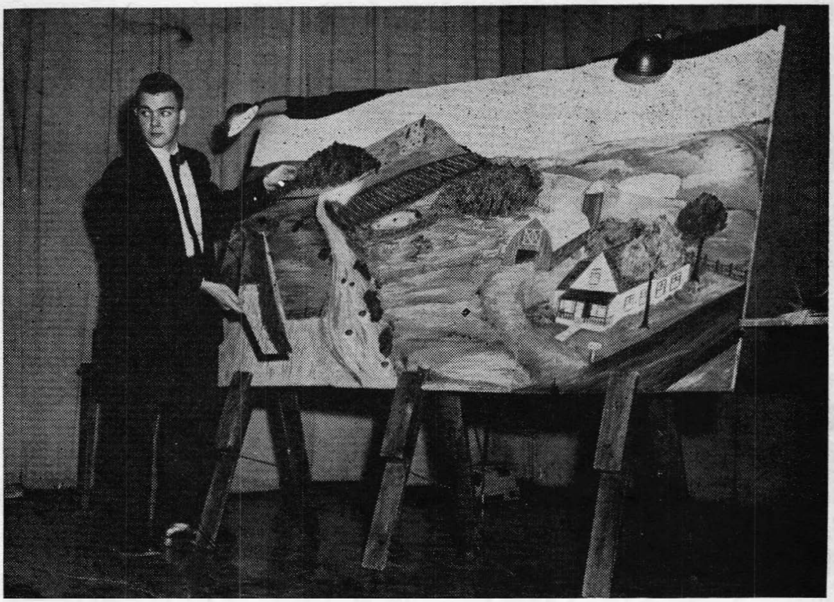

Fig. 4.
A woodlot and riprapping are about to be placed on the magnetic board. This is a new and valuable teaching aid.

Publicity for the series was handled by the press service of the College of Agriculture. A two page release and photo went to all of the local papers where I was scheduled to perform. In all, about 40 different publications of the article came to our attention. These ranged from the small town weekly to large city newspapers. *The New York State Conservationist, Field and Stream,* and the *Linking Ring* (magician's foremost magazine) also carried the story.

The schools were requested to return an evaluation report to Dr. Gustav A. Swanson, my adviser. In every case they would like the program repeated in future years, and rated student response from good to excellent. Reported one principal, "He did keep their attention very well—much to the envy of some of the teachers. . . . I was surprisd that he covered the material so thoroughly, appealing to so many varied interests. . . ." Others reported, "Student response was excellent . . . an outstanding program . . . a program of this quality would ordinarily cost us $35 . . . we were surprised by his ability to hold his audience—also impressed by his organization of materials and equipment . . . was presented at the level of the pupils, was graphic, serious but with enough humor to make it impressive. . . ." Some criti-

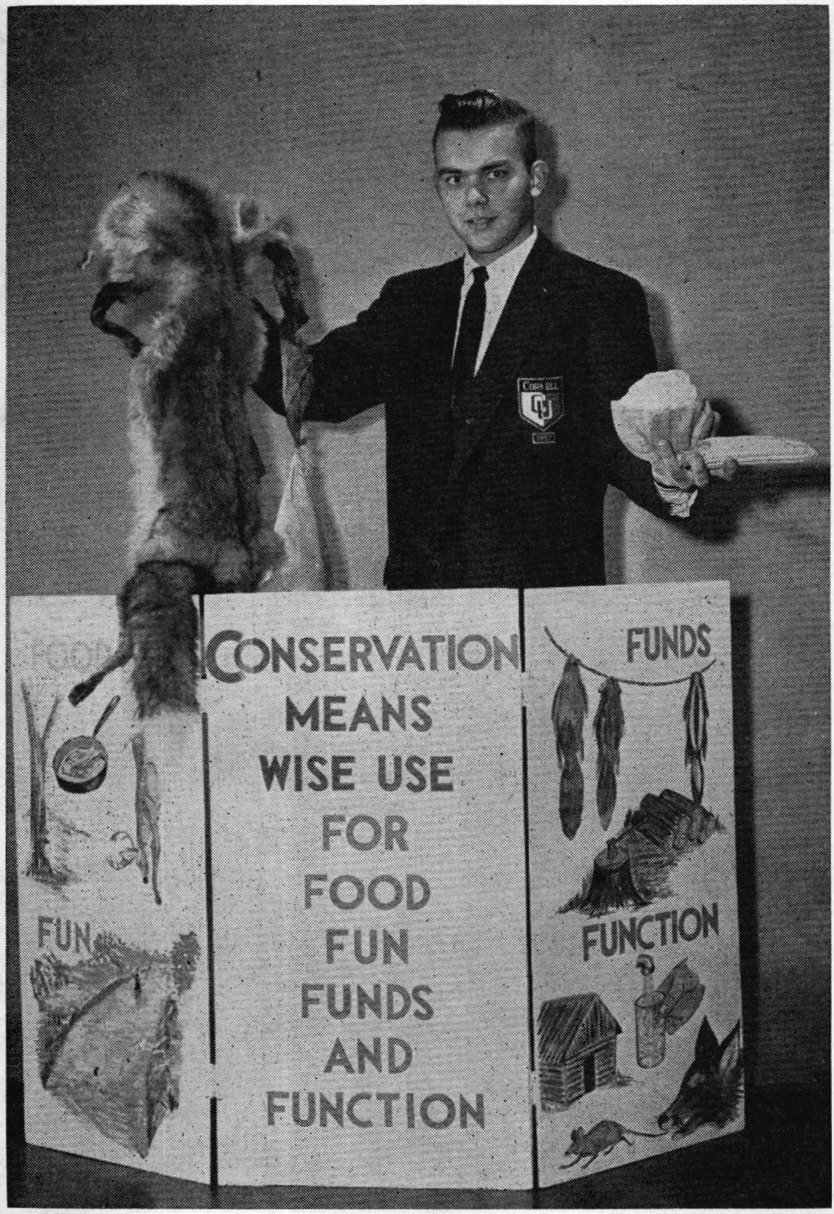

Fig. 5.
This photograph was used by many New York State newspapers to publicize David Hanselman's conservation by magic assembly program.

cal suggestions were made, the commonest being that the program was too long or included too much, but these were usually from schools where the principal had used a considerable time himself for matters not related to the program. Several schools returned reports of class studies which were initiated as a result of the program.

It is my belief that the assembly program affords great possibilities as a means of teaching conservation. A guest speaker appearing before a high school body has a definite advantage. To the student, the assembly programs are "special occasions" and are eagerly awaited. Consequently, if the program is interesting, a great deal may be taught. If interest is aroused, special reports, discussions, and assigned reading will be much more effective. One particular example is worth citing, as it illustrates this. Several themes written by a ninth grade science class were sent to Dr. Swanson along with the evaluation report. After viewing the program, the students were requested to write about conservation. The results were gratifying, indeed. They had used the reference booklets which I left at ach school, and had retained a great deal from the program itself. Several other schools indicated this same reaction.

I intend to continue presenting programs on a somewhat more limited basis to allow more time for study of their effectiveness. After graduation in 1957, I plan to begin a master's study which will evaluate extracurricular means of teaching conservation. The assembly program medium, I believe, has great possibilities (Figure 5).

PULLING TOGETHER FOR CONSERVATION—AN APPRAISAL OF THE CONFERENCE PROGRAM

I. T. BODE

Director, Missouri Conservation Commission, Jefferson City, Missouri

The approach to summarization of this conference is made in all humility, which arises from the deep respect in which the masterful work of predecessors is held. The pattern set by them is no easy one to match.

There is little chance of evaluating the wide diversity of interests, expressions of agencies and thoughts that this meeting brings together without offending someone, or to do it with the hope that there will be agreement on where most credit is due or what the real highlights are. May your judgment of the effort made herein to tie together the deliberations that have taken place be tempered with generosity, and may you allow in your consideration for sincerety, honest intent and desire to avoid prejudice.

It is my belief that there are two directions which any review or critique of a gathering of this nature should take:

(1) Toward consideration of those who have contributed directly by their willingness to participate actively on the program;

(2) Toward consideration of the contribution by those who supposedly come to listen, to learn from, and to extend by discussion the objectives sought.

I have often wondered how the sponsors themselves feel about such a conference. I doff my hat to those who are courageous enough to attempt to set it up. There can be no doubt about the need for or the importance of the things they are trying to do, but do they ever wonder how far the influence is extending beyond the confines of the "inner circle," so to speak?

How many of us who are here for the first time, or who have been repeaters frequently, or who, like some of us, have rarely missed, feel we deal largely in platitudes among ourselves? Do we feel that each year we experience the injection of new thinking, the stimulation toward more unified effort, the actual realization of sympathetic understanding of each others' problems? Do we come here to sell our own bill of goods, to establish our own cause as the only righteous path to salvation, or do we come with an honest desire to seek how we may all get into one set of harness and pull the same wagon in the same direction? How seriously do we take our own professions of our desires for cooperation and how seriously do we look toward recognition of the problems and rights of all interests concerned?

How diligently have we discharged our obligation toward those who have invested good dollars to send us here? Are we prepared to carry back to our own bailiwicks some of the wealth of knowledge and experience that has been exchanged? I am informed that the registration for this conference is somewhere around 940. How often has this hall seen an attendance of that number? Why, even at the first session, by the time it was half over, more than two-thirds of the audience had disappeared! Where have you been? I am very familiar, indeed, with the much belabored comment: "I get more good out of the bull sessions and room conferences, etc. etc., than out of listening to a lot of dry papers." This is not to depreciate in any degree the value of the opportunity a meeting like this presents for exchange of ideas and information on the special or individual basis. But, honestly now, isn't such an alibi for ducking conference sessions worked a bit overtime? If these side deliberations are so valuable to so many, why not bring them to the floor so all may profit? If the prepared program is so lousy that it does not deserve our time and attention, I am sure the means for bringing it up to our standards are easily at hand.

I presume to make this a part of my conference summary because, as stated earlier, there are two directions which any such review should take and one of them is toward the contribution made by those who come to listen, learn and discuss for the benefit of all. Enthusiasm and inspiration for mass accomplishment do not come from isolated and uncoordinated eruptions. The sponsors most certainly have strained every energy to make this event profitable to you. Have you made your proper contribution?

One is deeply impressed with a particular evident evolvement in these conferences. If you go back to the 1930's and the beginnings of this and other similar gatherings, and if you compare the delicacy of approach to vital problems and questionable situations then with the boldness and frankness of attack with which we face them now, and if you think of the things we now take for granted that in those days we scarcely dared mention—if you will take the trouble to do this, notwithstanding the discouragements and hurdles we still face, you must concede that progress has occurred along a number of fronts.

It would surely be amiss if some consideration were not noted for the controbutions by all those who have been so willing and generous in participating actively in the programs. Few of us appreciate what effort and energy goes into such participation. Few of us realize the courage it takes to stand before a heterogeneous group such as this and set forth one's honest opinions and thinking. Occasionally, roses are tendered. More often brickbats are the favors chosen, and they are not "tendered," they are thrown. So, we take our hats off in deep respect and with full appreciation to all those who appeared on this platform or in the technical sessions, whether we agree with what they had to say or not.

The sponsors of this conference and those who have devoted their time, energy and thought to the programs can take heart from the evidences of forward progress which were specifically apparent.

If Chamberlain's review, "The States Must Hold the Line," is a faithful digest of what is transpiring, and we believe that in the main it is, surely there is much of a heartening element in the increasing consciousness of the States as to assuming their just share of responsibility and initiative in conservation effort.

This coincides with Peterson's viewpoint with regard to the value of state agencies in this whole conservation movement because they are closer to the people than the Federal Governmnt and that, therefore, the recognition of the sovereignty of the states is an important element in any solution. Very encouraging was his viewpoint with regard to the small watershed act. The belief that the program was successful because it was of the local people and by the local people is not a new note but certainly an emphasis on a note that many feared had been lost in our national philosophy. We believe that when he so expressed himself he was actually thinking of the individual's interest and public right and not of vested interest.

Kluender expresses himself in a very similar vein and particularly so in his condemnation of the use of special interest as a basis for legislation.

The review of accomplishments as presented by Dr. Gabrielson is further cause for gratification. Such a review would have been impossible ten or fifteen years ago becase it just didn't exist. And there will be little disagreement with the conviction that a major factor in bringing about a revision of popular attitude toward the seriousness of conservation problems, and the motivation of people into articulate expression and telling action, is this very conference and its allied meetings and the interim programs resulting therefrom.

On the other hand, Dr. Gabrielson left little room for complacency in the picture he drew, especially of the changing character of the Fish and Wildlife Service and the disturbing procedure with regard to gas and oil leasing on Federal lands. While not session topics, these issues are of such concern that they have instigated continued discussion in allied sessions and in cloak room discussions throughout the days. We have heard the pros and cons and detailed explanations of how the present order of things came about. It is not this reviewer's province to pass judgment, but he would like to set out two ideas for thought. First, there has certainly been highlighted the necessity of searching diligently for full information on any issues of such vital importance before passing judgment; and, second, that the real solution to any shortcomings lies not in accepting the status quo, no matter how far it may date back, but in setting about changing it if it is bad. Can it be that, in the case of the controversy over gas and oil leases, for instance, we have an outstanding example where, no matter what our individual interests may be, we face a job of applying coordinated use and determination? No matter what we come up with as right or wrong, it is time for us to think.

It seemed to me that throughout these sessions I sensed more acutely than ever before that the rank and file of the public are thinking more deeply about conservation problems. Most striking were the warning signals, appearing with greater frequency, that the people are becoming ever more wary of *declared* good intentions, policies, administrative orders, etc., without any signs of deeds. They are beginning to wonder how much of it is window dressing being displayed in the spirit of appeasement to a yapping dog. They are growing weary of placing faith in such things only to see them followed by immediate steps of circumvention.

The first session, "What Conservation Means Today," brought us a wealth of *viewpoints,* if nothing more, relative to conservation concepts. But, there was more than that, of course. The boldness with which all, from the individual interest through to the public agency, the press, and the world-wide aspect, expressed their firm conviction as to the importance and need for conservation effort is clear evidence of some contribution toward clarifying conservation meaning. At least, we are left with the feeling that we need something. Also, I think we are left with little doubt that each interest or agency believes it has contributed something to accomplishment. Whether this has been in a separate and independent direction, or whether it totals up to mass movement forward with singleness of purpose, I am not so sure. One thing, however, seemed particularly evident to the reviewer and that was that, in all of the material presented by all of the varying interests, there was a fuller expression of appreciation of what unity of thinking means and more evidence than we have seen for a long time that some of the agencies which have been inclined to cooperate in words only are actually digging their teeth into the problem and attempting to carry a share of the load.

Mr. McCaffrey certainly highlighted one of the reviewer's early remarks to the effect that we are now speaking out boldly on things which only a few years ago we dared hardly mention. His presentation of the steps private forest interests have taken; his citation of data from the "Timber Resources Review," and his own comments comparing increases in timber production; his declaration of industry's interest in primitive areas, wildlife resources and recreational values; his picture of industry's demonstrated strides in research and education—these all are gratifying in the extreme. But, even they leave us with a number of unanswered queries about "Pulling Together for Conservation."

1. In the light of more detailed study of the "Timber Resources Review," are we left with a false sense of well-being?
2. Have the figures on progress been fully enough weighted against what the same report tells us concerning population, growth, future demands for forest products, and the remaining vacuum in the potential production of millions of acres of forest land?
3. If there has been the large increase in production on forest land; if there exists a great potential of production on extensive low producing areas; if there exists the sincere interest in a recognition of primitive areas, recreation requirements and related values, that is expressed in this paper; if so, why do we find ourselves in the position of having to wage unceasing vigilance and battle against the attempted inroads on such areas as the Quetico-Superior, the Olympic Peninsula Forest Reserves, and others? Why has the battle to eliminate the grab for timber under the guise of mining claims been such a bitter one? Why the now rumored report that such interests are threatening to scuttle the wildlife, forest and water provisions of the proposed soil bank legislation?
4. Of the hunting and fishing opportunity on industry's lands, how much of it is public opportunity and how much is of the private club or rental, income-producing type?

The pledges made in his closing paragraph are sweet music to many ears. We pray these may see fruition. We can heartily solicit such support for such things as adequate funds to the Forest Service to handle these interests on public areas.

All in all this part of the conference left little doubt as to the impact of the various phases of conservation effort upon each other. This was especially pointed out by McConnell in his review of the impact of agriculture on even urban population and became specific in connection with some of the things Durward Allen said. McConnell said one other thing that perhaps many of us can take to heart when he indicated that in trying to solve conservation problems, one is apt to find conservationists fighting conservationists.

Does all of this lead to a query that could be fundamental? While the expressions that we have had were in line with the original American concepts of government and individual initiative, have we already developed a generation for whom such philosophy will mean rather complete re-education in economic concept? And, how far has the psychology of individualism been translated into an interpretation as vested right and interest?

In view of the tremendous pressures in all facets of this conservation crusade, are individual agencies and individual states going to be able to cope with the problem? Are we going to have to save the above from themselves? (And I am far from being a socialist in philosophy!) Individual initiative and maybe even state effort hasn't gotten the job done. Who can piece together a coordinated pattern and a harmonious operation? Are we smart enough as a nation to get the job done under the patterns set here before we are forced by dire necessity to accept a dictation that we don't like or want bcause there is no other way out?

In the afternoon session Tuesday, the conference tackled the weightiest facet that exists in the whole conservation problem: "*How* to Get Coordination in Conservation."

Dean Wohletz gave us a pretty substantial platform upon which we can lay bare our souls. He presented comprehensively the complexity of the problem, but made it clear that complexity is no excuse for lack of action. No one should depart very far from his conclusions concerning the need for and value of research and education. The vendor of refrigerators, cigarettes, automobiles, and mouse traps learned those lessons. Some sectors of *conservation agencies* have learned to use these tools, and perhaps it is because they have learned to use them so well that they have been able to overpower and submerge all others. His anaysis of what needs to be coordinated, who should be educated, what information we must have and who should do the job leaves us with food for profound thought. He hit a keynote when he pointed out that too often and to a large degree emotions and biases act as the basis of policy for conservation of natural resources and add too often to the existing confusion.

We, as citizens, are prone to sit in a meeting of this type and to judge or hurl invectives at public officials and agencies for abuses, selfish promotion, and all their other offenses, when perhaps some of our steam should be directed in another manner. This is not to say that these agencies all too often have not been pretty blind to "coordinated'' conservation effort. Threaded throughout the thinking that all of us must do, however, as we try to digest the meat of these presentations, runs a fundamental query. If our interests are still so diversified in direction; if we have made no more progress toward actual coordination than we have; if, as was indicated, certain agencies have been as successful as they have been in heading toward a common objective, and otherss not—then, where do the roots of the problem reach?

We could well wish to see on the panels of a meeting of this kind a fuller exploration of how far such confusion in direction, and confusion in law and mandate, is grounded in the urging of the public itself. How far are you as a private citizen responsible for the single-mindedness and lack of approach from the broad, human welfare aspect? One needs only to review his own acquaintance with attitudes of civic organizations, chambers of commerce, state and municipal promotional agencies, organized specialized associations, and others, to realize that the ordinary concept of human economics gives us very little beyond that upon which a dollar sign can be hung. Maybe a conference of this kind should concentrate more of its energy upon developing a new school of thought in the minds of John Q. Public.

Between the background for conservation thinking, as set forth by Wohletz, and the stimulus to profound analysis of conservation objective (no doubt somewhat startling to many), as suggested by Allen, there lies a large area for examination. It is that area wherein, today, we are trying to thread our way. It asks: what steps *have* we taken; are there any evidences of improvement in the condition of the patient?

One pattern is suggested by Curtis as he emphasizes the importance of the kind of legislation which defines objectives and provides general patterns of operation but leaves to subsequent executive decisions the ways and means of reaching desired goals. He illustrates this principle with executive decisions made by the TVA Board and what the outcome has been, and his detailing of the accomplishments of the TVA certainly dictates the wisdom of our reviewing any preconceived notions we get before passing judgment on the success or failure of any plan. While business-wise there probably would be little argument with the principle of legislation suggested here, the question not yet answered, but all-important, is "how far can you go in this direction in our form of government without the people relinquishing the liberties they have taken so much pride in"? There are, of course, vociferous advocates on both sides of the question. No resolving of it would be possible here, but two important facts are highlighted by this paper: (1) re-emphasis on the complexity of the problem and diversity of interests that must be dealt with, and (2) that, if Mr. Citizen is not willing to broaden his own generosity of thinking and his concept of what is required for the sake of public welfare *in all fields,* or is not *willing* to do so because of selfish outlook, someone will very likely have to do the job for him and force it down his throat if for no other reason than self-preservation of our human population.

That this need not be was illustrated by Hale as he related the progress of the Northeast Elks County Soil Conservation District. What has occurred there seems to bear out Peterson's earlier remarks concerning the place of local groups. This was a natural, grass roots presentation of local responsibility in action and highlighted the potential accomplishments through this sort of effort as contrasted with the conflicting efforts of many of the Federal agenices. As Mr. Hale put it in effect, there were a lot of Federal agencies all trying to carry out different programs and the land got the hell. In reviewing this paper, one cannot help but wonder whether or not the sun has broken through the clouds? Will the people absorb conservation if given an opportunity that is not all befogged by selfish interest and bureaucratic ambition?

How important all this could be for future national welfare was highlighted in the paper by Durward Allen. He maintains that we have been blindly dedicated to a creed that, at all costs, our economy must perpetually expand, and he questions whether we are at a point where quantity must cease to be the great issue and must give way to a more mature and stable outlook with a first concern for quality of our living and our understanding of husbandry of man. No doubt his analysis of population growth by virtue of "habitat" and his startling revelation, supported statistically, that in the name of what we call "economy" we are not only jeopardizing our living standards but are also destroying a resource with a nine billion dollar a year business turnover, leave us wondering if, after all, we haven't circumscribed a maladjusted concept of economics to the ultimate conception of public welfare. We wonder who prescribed our present conception of "economics"? Who determined that nothing had "economic" value that could not be hung with a dollar sign? Will we be able to comprehend the significance of Allen's statement: "What the taxpayer is really buying with his squandered dollars is an America of the future crammed to the waterline with citizens who will be forced inevitably to a lower standard of living."

And, sorry to say, even some of the supposed leaders of conservation thought and effort are not blameless in this regard. Whether it be lack of insight, pressure of constituency, entrenchment of personal position or other motive, we are too often faced with the unpleasant truth that leaders, even administrators (and with full knowledge that I am not popular for saying so), find a way to justify anything they want to do, regardless of what it means to long-time public welfare. May I point out that the use of "administrator" here is not confined to Fish and Game and Conservation departments; its reference is to all administrators who deal in conservation, no matter where they are found.

Perhaps Woerpel in his paper this afternoon, "Fumbles at the Goal Line," hit a keynote when he said that most of our fumbles were due to a lack of honest belief in the importance and loftiness of the cause that many have dedicated their lives to.

He indicated that we are not convinced that our cause is as important, if not more so, than that of Industry, Business, and the Public Utility. He also emphasizes our distorted concept of economics by the examples cited, especially his quotation from the last Department of Agriculture Yearbook. This is what Woerpel says: "The latest Department of Agriculture's Yearbook, 'Water,' contains this gem, 'Excess water becomes a problem when it interferes with tillage, land preparation, the development of plants, and harvest operations.' Do you think that the people who wrote that believe that conservation goes any farther than drainage and bumper crops?"

An underlying theme in this whole session was that if there is to be a "Pulling Together for Conservation" it must stem from the grass roots up, as well as being guided by honest purpose from the top.

The challenge that Mr. Winston Mair threw out is so fundamental that it is worthy of noting. He said: "We are, however, an all-star team, drawn from State, Provincial and two Federal agencies, as well as some private agencies, and we have suffered from the lack of team practice. But, we have been at this some time now and we should be improving our team work. We should be prepared to forego personal high-score ambitions, prima donna notions and local jealousies. We must be prepared to examine what is best for the team and the continental population it represents, and then play our parts to the full."

His clear insight into the future and his honest picture of the Canadian situation leaves us with a feeling that he is a bit too modest about Canada's place being only one of coaching in the backfield. They have played and they will play a much more important role than that. We know it. Can we on this side of the border reciprocate when Mr. Mair says, "Canada as a whole, as custodian of the greater part of the continental waterfowl breeding grounds, has a responsibility to the sportsmen of the North American Continent extending beyond national or provincial boundaries''?

In contemplation of the whole conference, it can be said that it is certain that no one yet has come up with a formula which comes anywhere near accomplishing the coordinated effort we envision. We do see, nevertheless, certain most heartening sign posts pointing ahead, in spite of the morass of confusion that still exists.

In attempting a summary of the technical sessions, one is immediately confronted with the question, ''From what viewpoint should it be done?'' There are several viewpoints that could be assumed, any one of which could be at odds with the other and yet each be correct in itself. Perhaps no one person is broad-visioned enough to attempt all approaches. Perhaps the time has come when, from year to year, it should be determined not only who is to appear on the program, who will chairman the various divisions and what the general subject matter will be, but, as well, what the *objective* of the technical presentations is to be.

For example, is the objective of this part of the conference:

(1) To simply present new material, findings and advances in the technical field regardless of any application to practical problems?

(2) To serve primarily as a vehicle for the research worker to accomplish publication of his findings?

(3) To concentrate on those things which are apt to contribute most directly to solutions of the human and management problems as developed in the general sessions?

Any one of these objectives is very laudable in itself, but each is apt to center around and attract a special group of program participants and interested listeners. Perhaps there is a value in mixing things up and giving a little of all. I think this conference has done that. The suggestion is made that serious thought be given to objective No. 3. If the technical sessions could be developed in coordination with the general sessions, the result might be a strengthening of the general theme of the conference, and a deeper impression upon the minds of those attending, by virtue of the support that current research findings would give to the deliberations—pro and con—of the general sessions. Now, I trust that no one will place any interpretation on those remarks as belittling in any way the high quality and value of the more strictly professional and technical material presented.

The technical sessions, in the reviewer's opinion, give rather clear indications of definite trends:

(1) That there lies ahead of us in the wildlife management field a vast realm of the unexplored, in spite of the amazing progress we have made.
(2) That no sane game management administration can hope to keep abreast of its problems in discharging its service to the public without honest and sound research.
(3) That research work out dates present concepts at a rapid rate and that both research and administration have a real problem in currently absorbing and getting constituency to absorb the changes in thinking and procedure that research dictates. The rate with which refinement of former work and technique is occurring almost bewilders us, but it is clear evidence that wildlife management is steadily becoming a respectable profession.
(4) That research is becoming more and more conscious of the administration and management application problems and the close association of research with these.

What clearer picture could be found of our circumscribed evaluation of conservation and economic values than was left us by Lostetter in discussing, "Environmental Control in Waterfowl Management"? What this paper really delineates, though it may not be expressed in so many words, is the tedious, expensive process involved in our attempt to build back even a small portion of what we so blithely and thoughtlessly did away with. And one cannot consider this paper without going far enough afield to wonder why in the name of all common sense and reason, in the face of the dire situations we now face, those governmental agencies in whom we have placed our trust for safeguarding such a national resource are the very ones to become parties to legislation and administrative orders to pounce full tilt and pronto upon this wildlife weakling as a display of effort to solve land use, agricultural production and industrial problems. It can be no more than a pretentious gesture because, as a vital element in the real economic problem, such a thing as the production of foods for waterfowl is infinitesimal in its impact. In the vernacular of the common man, to many of us, "it stinks." But, let us be generous enough to hope that some of these decisions and policies are a result of generalizations, which in themselves might have foundation but the implications of which, in blanket application, were not thoroughly thought out. Salyer's account of the waterfowl situation is lucid, even though disheartening. It raises, as do the foregoing, the question of what belongs in our definition of economics.

Again it is difficult to understand our interpretation of economics in the face of information such as presented to us by Renn on "Man as a Factor in the Coastal Environment.'' There is perhaps nothing so *new* in this paper, but it gathers together, into a composite picture that jars us, a lot of disjointed thoughts that have been wandering about loose. Can anyone reconcile our profligacy with our coastal waters with the billions of dollars we spend for parks, health research on disease, youth rehabilitation, moral uplift and other humanitarian efforts? It not only doesn't make sense, it smells to high heaven, and you, Mr. Citizen, may be responsible in a large measure for the stench because of your indifference and the private interest you may have in the effort and expense it would take to clean up the mess. Wherein lies any economics in such a situation?

Presnall's discussion of predator management stands as another classic example of the relationship between research and application referred to in this review and of the stubborn adherence to old prescriptions notwithstanding enlightenment from new findings. Very few phases of wildlife management, if any, antedate discussions, theories, ideas, approaches and controversies over what a predator is and what to do about them. Yet, only within the past decade, according to this author, have we seen pronounced changes in our thinking and predator control practice. Among the most amazing of the comments he makes is that ''one of the most notable *trends* in predator management is *the increasing desire* on the part of administrators and technicians to discard bounties.'' Oh, the price we have paid for stubborn adherence to precedent and jealous pride of self-determined knowledge! In the *whole* wildlife management field Presnall's closing comment is all too applicable when he says, ''too many cinemascope viewers of today are still in the silent movie era so far as predator management (and we add wildlife management) is concerned.'' The papers by Lostetter and Renn further substantiate these observations.

That the vast unknown overwhelms us is borne out by the picture Phil Goodrum painted, with its principal component the frightening implications of what misguided hardwood and brush control could mean. And Fay, Boyce and Youatt, in their presentation of ''An Epizootic in Deer in Michigan,'' surely should deflate any ego that anyone—layman, manager, administrator, or technician—might have as to our having arrived at all the answers. Here comes a new element that could challenge much of our presently accepted satisfaction in past knowledge of dynamics of deer population. Then, we cannot help but cringe at the picture that Kiel and Harris paint of the white-winged dove in Texas. ''Another Threatened Species'' is the only label we can give it. The unknown?—What can be done about it in the face of other impacts involved? One thing is sure, complacency is no solution.

We shall have to depart a long way from present concepts in waterfowl management if what Craighead and Stockstad found in Montana, relative to the dynamics of hunting pressure on Canada geese, becomes the accepted foundation of management. If we do accept such alterations, we, as waterfowlers, will need to modify radically our present notions about what we can and cannot do.

And so one may browse his way through all the material of all these sessions and find indicator after indicator of three definite trends:

(1) That daily our knowledge of wildlife management is becoming more precise.

(2) That management cannot go forward until all of us have the honesty to reach our judgments on the basis of facts—not on the basis of tradition, surmise and unsubstantiated theorizations.

(3) That thinking, planning, seesawing for recognition, and greed for a share from the gravy barrel are still all too often shooting off in every direction.

The technical session this morning on "Conservation Education," was most encouraging from the standpoint of progress. It was so, perhaps not so much from the standpoint of volume, but more because of the clarity of direction voiced and the closeness to unanimous thinking in working out a formula for operation. The thread of thinking does two things. It reflects back from a crystal clear mirror an unadorned and realistic image of the functioning of the average man's mind with regard to the elements involved in the conservation problem, and these comments constitute a challenge for self-examination on the part of any would-be conservationist.

The conclusions of Wagar and Steinhoff, with regard to the improvement of teaching procedures, character of conservation officers and progress in thinking, are refreshingly encouraging. They set forth a down-to-earth pattern for an objective in wildlife administration and accomplishment that would be hard to disagree with.

Shomon and Myers mince no words in presenting boldly what the deterrent and dangerous results of uncoordinated programs can be. Then come Short and Wade, not with theories and proposals, but with demonstrations of how to get the job done. And let no one tell me that the technician cannot devise the tools to get his information beyond the buried pamphlet. If there is any highlight of the Educational-Informational phase of this meeting, it is the demonstration given us of the way to do it by Severy and Pengelly and by Hanselman. Anyone who missed this missed a prime lesson in putting theory into practice. And the smart technician is the one who draws inspiration and example from what these men demonstrated this morning.

In conclusion, if I were to put into a few words my own over-all impression of this conference (in spite of the "griping" I may have done herein, and in spite of the setbacks which continually show their heads), it would be about as follows: As dark as the clouds still seem, as confused as the various conservation concepts and philosophies still appear, as disheartening as many of our strivings prove—there begins to become visible (1) a directional movement being impelled more and more by an increasing consciousness on the part of the masses of essentials; and (2) a clearer warning beacon to bureaucracy, to vested interest and to individual greed that there *is* a public interest in our natural resources and that the people are not going to be pushed around much longer.

Ladies and gentlemen: that is my appraisal. If it is bad, blame me, not the sponsors of the conference. If it contributes something toward forward progress, the effort will have been worth making.

ACKNOWLEDGMENT OF APPRECIATION

C. R. GUTERMUTH

Vice-President, Wildlife Management Institute, Washington, D. C.

Friends, while I agree wholeheartedly with Mr. Bode that we sometimes do not have as many people as desired in the meetings, I must say that it is most refreshing to see several hundred people in this room now, at 5:25 p.m., on the last day and at the close of this Convention. I believe that all of you agree that this has been another highly successful conference.

As I listened to that splendid thought-provoking critique by Mr. Bode the full realization of the magnitude of the job of appraising the entire program of such a large international meeting came back to me in no uncertain terms. The Chairman of the Northeastern Wildlife Conference talked me into summarizing that large program in Atlantic City last year and, believe me, I know that it is an arduous task. You did an excellent job, Mr. Bode, and in searching for appropriate words of praise it makes me appreciate that a mere expression of thanks is inadequate.

In behalf of the sponsoring organization, the Wildlife Management Institute, I wish to thank you, Mr. Bode, and all of the organizations and agencies and individuals who have contributed to the success of this year's conference.

We wish to thank the members of The Wildlife Society and John Gottschalk in particular. While we are grateful to all those on the Program Committee, which, as you know, includes practically all of the national conservations organizations, I want to say that John did an excellent job. He followed through on every detail in his unique manner and the program of the technical sessions reflected his efforts.

I have not read a newspaper for several days but there is no doubt about the good coverage that was given by the newspapers and the wire services, the magazines, the radio and television.

In your behalf and that of the Institute, thanks to the Jung Hotel and the New Orleans Convention and Visitors Bureau. There were few complaints and we are indebted to the Bureau for the efficient handling of the conference registration.

It was evident that you enjoyed the banquet last night. I watched the audience and in view of the fact that New Orleans is famous for a certain type of entertainment, it was reassuring and gratifying to see that high quality entertainment appeals to most of you. The musical and variety show produced by Jack Morton Productions was up to standard. You may be sure, however, that it is getting harder each year to hold to the quality that we try to provide.

The members of the Institute staff are always glad to see these large annual conferences come to an end, and before closing, I would like to say a couple of things. We have discussed about everything else during these three days, and as I look out over the audience at this closing hour and see all of the wives, I am delighted. We never hear much about the wives at these conferences.

That wife of mine, for example, was a black-haired, curly-headed lass thirty-four years ago and she has put up with me and conservation all this time. Then I see other patient and loving wives here, all of whom have contributed much to the success of conservation. I am not going to ask all of them to stand, even though they do deserve a lot of credit, but, when it comes to the long months of work that it takes to put on a meeting of this kind, and when I know of the patience and endurance of those like Mrs. Gabrielson and Mrs. Gutermuth, then I think that they in particular are worthy of a hand and I wish that they would stand. [Applause]

In conclusion I would like to say that the registration came up to expectations. We never can get more than about 75 per cent of the people to register, and they have 926 enrolled. That means that we had well over 1,000 in attendance. There were 648 people at the banquet last evening. That is above the average. The largest banquet attendance we ever had, I believe, was something like 838 at the 1953 conference in Washington.

Although it would be nice to have everyone enroll, the attendance record if not our measure of the success of these yearly conferences.

Although it would be nice to have everyone enroll, the attendance record is not our measure of the success of these yearly conferences. The interest and participation in the discussions, and the personal contacts that are made, really are important. Furthermore, if these conferences did little more than reflect the current trends in such splendid appraisals as Mr. Bode's, then the yearly get-togethers would be justified. We will try to have his summary multilithed and mailed within ten days. Those of you who would like to have a copy in advance of the proceedings, please put your name and address on this pad and we will get a copy to you as quickly as possible.

Now, we are going to do something that seldom has been done. Only on one previous occasion have we announced where the next conference is to be held. I have the privilege and pleasure to say at this time that we will return to Washington next year; to the Washington Statler. The dates will be March 4, 5 and 6. It is hoped that we will get to see all of you then.

Again, thanks, have a safe trip home and happy landings.

REGISTERED ATTENDANCE AT THE CONFERENCE

ALABAMA

Ralph H. Allen, Jr., George A. Averitt, Percy L. Beech, Mrs. Percy L. Beech, William D. Boyer, Paul Bryan, Alma Bryan, L. B. Byrd, J. H. Crow, Jr., Mrs. J. H. Crow, Jr., Edwin F. Davis, Verne E. Davison, Mrs. Verne E. Davison, W. H. Drinkard, Mrs. W. H. Drinkard, Tom Ford, Mrs. Tom Ford, A. J. Harris, J. W. Harris, Arnold O. Haugen, John L. Heflin, Graham Hixon, W. L. Holland, Jr., Archie D. Hooper, C. H. Jackson, Claude D. Kelly, Earl F. Kennamer, Hubert Kimbrough, Mrs. Hubert Kimbrough, George M. Kyle, Sidney P. Landry, Gilbert W. Melcher, William H. Moore, G. W. Ponder, Jr., H. M. Roller, Jr., Dan W. Speake, Fred T. Stimpson, Mrs. Fred T. Stimpson, E. C. Suttle, H. S. Swingle, Reynolds W. Thrasher.

ALASKA

A. W. "Bud" Boddy, John L. Buckley, Frederick C. Dean, Glenn W. De Spain, Wallace Fitzgerald, Edward P. Keough, Gordon W. Watson, Jo Anne C. Watson.

ARIZONA

Fred Faver, John M. Hall, Lyle K. Sowls, Wendell G. Swank.

ARKANSAS

William J. Allen, Mrs. Willliam J. Allen, S. C. Dellinger, D. N. Graves, Mrs. D. N. Graves, Andrew H. Hulsey, T. A. McAmis, Joe Robonson, James H. Stevenson.

CALIFORNIA

Will Dale Auerbach, Harold D. Bissell, David R. Brower, Warren P. Chase, F. P. Cronemiller, Mrs. F. P. Cronemiller, Benjamin Draper, George D. Difani, Ben Glading, Seth Gordon, "Bill" Harp, Luther G. Hester, Harley E. Knox, Mrs. Harley E. Knox, C. H. Lostetter, John C. Mitchem, Paul M. Scheffer, Richard D. Taber, Walter P. Taylor, Mrs. Walter P. Taylor, Joseph F. Thornton.

COLORADO

Basil K. Crane, Robert W. Davis, Gilbert N. Hunter, Thomas L. Kimball, Joe Penfold, Wm. L. Reavley, Harold W. Steinhoff, Cecil S. Willliams, Lee E. Yeager.

CONNECTICUT

Philip Barske, Mrs. Philip Barske, Jane Barske, Wallace Bowman, Belton A. Copp, Henry P. Davis, John Dear, Jack D. Mitchell, Mrs. J. D. Mitchell, William F. Petras, Mrs. Willliam Petras, John R. Schaefer, Lyle M. Thorpe.

DELAWARE

William Baxter, Mrs. William Baxter, Henry P. Cofer, T. E. Doremus, Mrs. T. E. Doremus, Wilbert Rawley, Austin D. Smith, Norman Wilder.

DISTRICT OF COLUMBIA

Edward T. Aud, W. Lester Bagley, John B. Bennett, Stewart M. Brandborg, Max W. Bridge, Carl B. Brown, J. A. Brownridge, Mrs. Katharine W. Bryan, Charles C. Butler, Chas. H. Callison, Mrs. Chas. H. Callison, Henry Clepper, Lawrence V. Compton, James B. Craig, George Crossette, Frank Daniel, Albert M. Day, Mrs. Albert M. Day, Wesley A. D'Ewart, Everett R. Doman, John L. Farley, George S. Fichter, John Findlay, Gordon Fredine, Ira N. Gabrielson, Mrs. Ira N. Gabrielson, R. E. Griffith, C. R. Gutermuth, Mrs. C. R. Gutermuth, Wm. Hagen, Jr., Gove Hambidge, Michael Hudoba, John H. Jones, Joe Linduska, Eileen Mair, O. L. Meehan, Milo Moore, Fred M. Packard, Joseph F. Pechanec, Daniel A. Poole, Clifford C. Presnall, Harry E. Radcliffe, Mrs. Harry E. Radcliffe, Paul W. Reed, R. M. Rutherford, Carl D. Shoemaker, Mrs. C. D. Shoemaker, John L. Sincock, Richard H. Stroud, Ernest F. Swift, Mrs. Ernest Swift, Lloyd W. Swift, James B. Trefethen, Robert A. Wells, R. W. Westwood, Mrs. R. W. Westwood.

FLORIDA

A. D. Aldrich, Ralph Andrews, J. W. Bickerstaff, Mrs. J. W. Bickerstaff, Howard R. Bissland, E. B. Chamberlain, Jr., James H. Dahlen, S. H. Du Bon, Mrs. S. H. Du Bon, O. Earle Frye, Gordon E. Hall, Arthur W. Henn, Mrs. Arthur W. Henn, Frank J. Ligas, Charles M. Loveless, Scott Overton, Jim Powell, Donald D. Strode, W. Turner Wallis, Mrs. W. Turner Wallis, Matt H. Whisenhunt, Mrs. M. H. Whisehunt, H. R. Wilber, Louise Wilber, Frank Winston.

GEORGIA

Roy W. Bixler, John Blosz, Phil H. Bryan, Jack Crockford, Fred J. Dickson, Mrs. F. J. Dickson, Carl R. Eklund, Mrs. Carl R. Eklund, Charles N. Elliott, Leonard E. Foote, W. A. Gresh, Roy Grizzell, James H. Jenkins, C. Otto Lindh, Fulton Lovell, Wm. T. McGlothlin, George B. Saunders, Hugh W. Terhune, Mrs. Jeanne L. Terhune, Ernest Tierkel, John E. Wood, Lewis A. Young.

IDAHO

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